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Coastal and Hydraulics Laboratory

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Navigation Study of Lower Lock Approach, John Day Lock and Dam, Columbia River, Oregon

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Final report

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Preface

This investigation was performed by the Coastal and Hydraulics Laboratory (CHL) of the U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS, for the U.S. Army Engineer District, Portland (NWP). The study was conducted in CHL during the period January 1999 to July 1999.

During the course of the model study, representatives of the Portland District and other navigation interests visited ERDC at different times to observe special model experiments and to discuss the results of those experiments. The Portland District was informed of the study's progress by monthly reports and special presentations at the conclusion of each experiment.

This report is being published by ERDC, CHL. CHL was formed in October 1996 with the merger of the ERDC Coastal Engineering Research Center and the Hydraulics Laboratory.

The first-line review of this report was conducted by Dr. Sandra K. Knight, Chief of the Navigation Branch, CHL. The principal investigator in immediate charge of the model study was Mr. Donald C. Wilson, PE, assisted by Mr. David M. Maggio, and Ms. Peggy S. Van Norman, all of CHL.

Acknowledgment is made to Messrs. Chris Goodell, Bob Buchholz, and Ms. Diana Modini, all of CENWP-EC-HD, Mr. Matt Hanson of CENWP-EC-DS, Mr. Rock Peters of CENWP-PM-E, and Messrs. Dennis Stocks, Mike Graves, and Don Chaffee, all of CENWP-CO-D for cooperation and assistance at various times throughout the investigation. Special thanks go to Columbia River Towing Association for participating in the study.

At the time of publication of this report, Dr. James R. Houston was Director of ERDC, and COL James S. Weller, EN, was Commander.

1 Introduction

Location and Description of Prototype

John Day Lock and Dam is located at the head of Lake Celilo, 347.6183 km (216 miles) upstream from the mouth of the Columbia River (Figure 1). The dam crosses the river near Rufus, OR, about 40.2336 km (25 miles) upstream from The Dalles, just below the mouth of the John Day River.

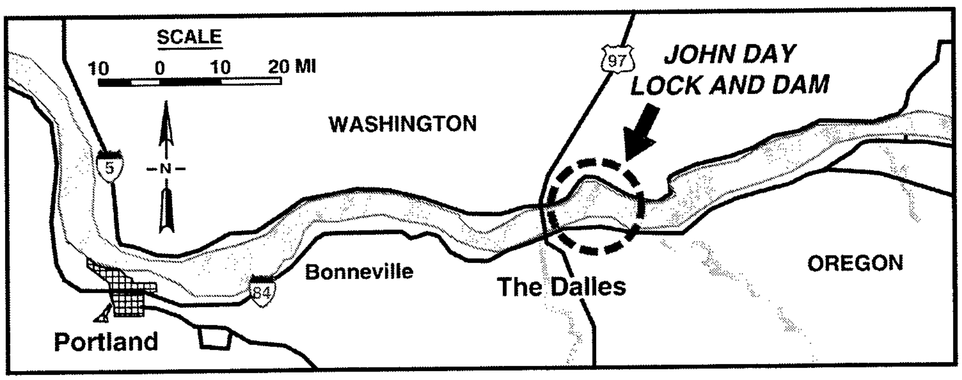


Figure 1. Location and area map (to convert miles to kilometers, multiply by 1.609347)

The project consists of a navigation lock, spillway, powerhouse, and fish passage facilities on both shores (Figure 2). Lake Umatilla, impounded by the dam, extends upstream about 122.3101 km (76 miles) to the foot of McNary Dam. Various recreational facilities are provided along the shores of the lake and on the John Day River. Construction began in 1958 and was completed in 1971, at a cost of $511 million. At the time of its completion, John Day Dam Powerhouse was the second largest in the world. Completion of the John Day Dam marked the final step in harnessing the lower waters of the Columbia River.

History of Project

The U.S. Army Corps of Engineers and others have constructed 18 dams along the Columbia and Snake rivers system since 1933. These dams have been constructed to provide electric power, flood control, farmland irrigation, and

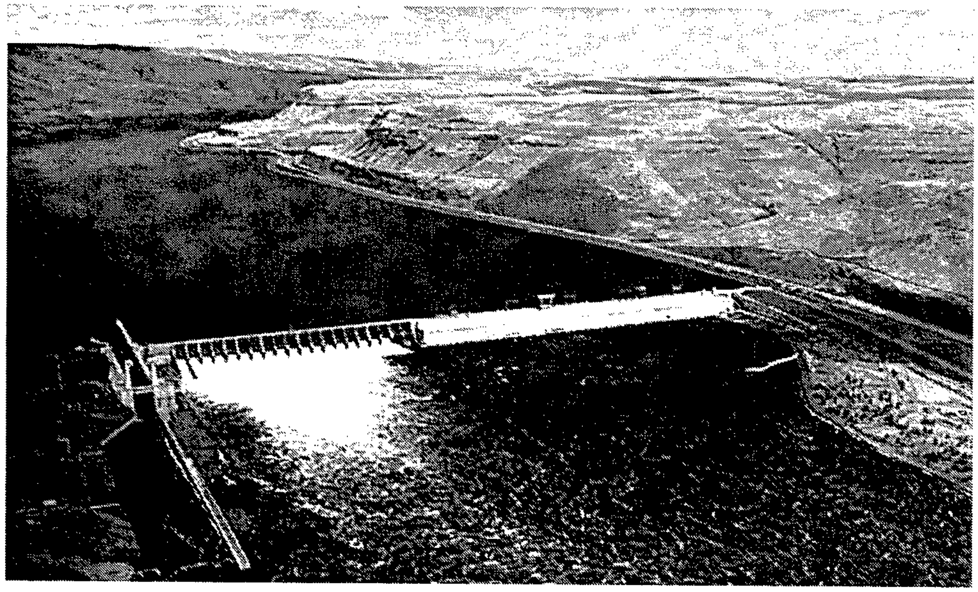


Figure 2. John Day Lock and Dam

towboat navigation. While providing these benefits, the dams have also had some negative impacts on annual fish migrations, particularly to salmon and steelhead trout.

When juvenile fish migrate downstream toward the sea they normally follow the main flow of the river. When discharges are low, all of the flow at John Day Lock and Dam is passed through the powerhouse to produce electricity. Therefore, the main flow of the river guides the juveniles to the powerhouse and the deadly turbines. When the discharge is higher than the capacity of the powerhouse, the excess discharge is passed through the spillway. Historically at John Day, as the discharge increased above the capacity of the powerhouse, the spillway gates would be opened beginning with gate no. 20 next to the powerhouse and then gates would be opened systematically toward the middle of the spillway as required. When about one-third of the gates were in use, gate no. 1 would be opened slightly and gates would be opened toward the middle again. At all times, the discharge distribution through the spillway would be heavily weighted toward the powerhouse side of the spillway. The spillway was operated this way so the juvenile fish following the main flow toward the powerhouse would have a better chance of diverting to the flow passing through the spillway where they would have a better chance of surviving. However, it was determined that the large gate openings at the powerhouse end of the spillway caused excessive gas levels in the tailrace, and the concentrated flow caused a large clockwise rotating eddy in the tailrace that served as excellent habitat for predator fish.

Therefore, experiments were conducted to develop spillway patterns with smaller gate openings and more uniform flow distribution across the spillway to reduce gas levels and predator habitat in the tailrace.

Another modification that has been implemented at several projects is spillway flow deflectors. Flow deflectors are added to the downstream face of the

gated portion or spillway of the dam. While reducing the level of dissolved gas, these flow deflectors also significantly change the flow conditions in the tailrace. Flow deflectors as shown in Figure 3 were added to bays 2-19 of the John Day Dam. Construction of the flow deflectors was completed in February 1998.

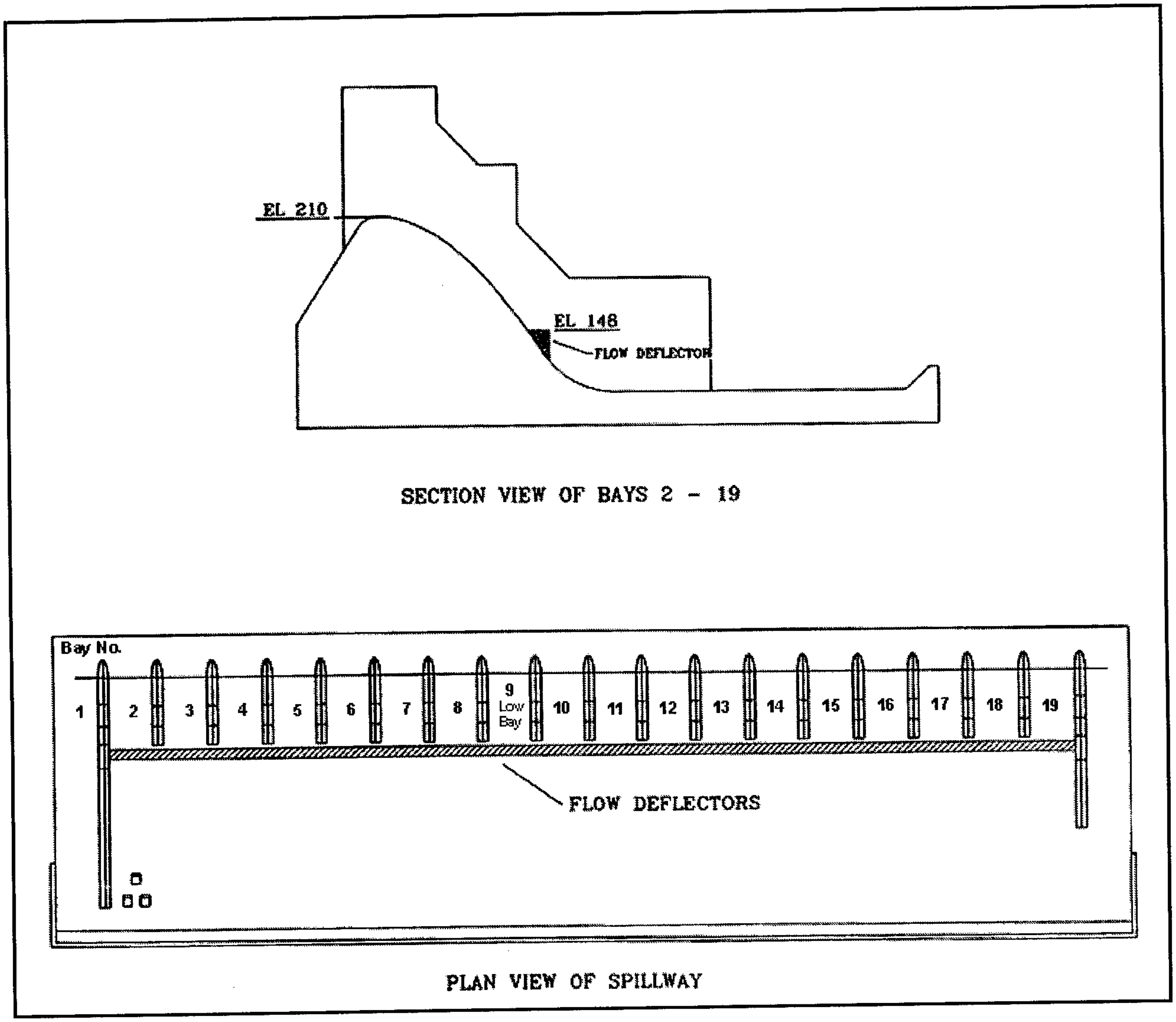


Figure 3. Flow deflector (not to scale)

According to representatives of the Columbia River Towing Association, the installation of the flow deflectors and/or change in spillway operation at the John Day project has negatively impacted navigation conditions in the lower lock approach during spillway releases. They reported that the flow deflectors increase the tendency for tows to be pushed toward the right descending bank as they approach or exit the lower lock approach. Incidence reports provided to the U.S. Army Engineer Research and Development Center (ERDC) by the U.S. Army Engineer District, Portland, are shown in Figure 4. Meetings and conference calls with representatives from the towing industry, the Portland

District, and ERDC were held to discuss the incidences and possible remedies. Based on these discussions, the towing industry requested that system modifications be investigated to resolve or improve navigation difficulties associated with the recent structural and operational changes at the dam.

Date	Time	Boat	Owner	Direction	Total KCFS	Turbine	Spillways
May 6	1630 Hrs	Clarkston	Foss	Down	351.9	249	100
Spill Pattern		3 5 5 5 5 4 4 4 4 3 3 3 3 3 3 3 2 2 0 0					
May 16	1245 Hrs	Legend	Tidewater	Down	339.9	249	84.1
Spill Pattern		3 5 5 4 4 4 3 3 3 3 3 2 2 2 2 2 2 1 0 0					
Mat 16	1400 Hrs	Cascades	Shaver	Down	340.5	255.5	84
Spill Pattern		3 5 5 4 4 4 3 3 3 3 3 2 2 2 2 2 2 1 0 0					
May 24	1030 Hrs	Captain Bob	Tidewater	Down	326.1	248.6	74.6
Spill Pattern		3 5 4 4 4 3 3 3 3 2 2 2 2 2 2 1 0 0 0					
May 24	1600 Hrs	Kathryn B	Bernert	Up	350.9	248.1	100
Spill Pattern		3 5 5 5 5 4 4 4 4 3 3 3 3 3 3 3 2 2 1 0					

Figure 4. John Day incident report

Need and Purpose of Model Study

The 1:80-scale physical model of John Day Lock and Dam at ERDC, CHL, was originally constructed to investigate proposed structural and operational modifications to improve passage of adult and juvenile migratory fish.

Because of the navigation concerns expressed by the Columbia River Towing Association, the model is also being used to identify the impacts of spillway flow deflectors and spillway gate opening patterns on barge traffic in the lower lock approach. ERDC was tasked with documenting and evaluating current patterns and navigation conditions with pre- and post-deflector conditions with the 1997, 1998, and 1999 spill patterns (see Appendix A) provided by the Portland District. Once these impacts were identified, ERDC was to investigate structural and operational modifications that could improve navigation conditions in the lower lock approach.

2 Physical Model

Description

The general model of John Day Lock and Dam, Columbia River, is a 1:80 scale reproduction of about 11.2654 km (7 miles) of the Columbia River, extending from river mile 212.5 to mile 219.5. The model is of the fixed-bed type, with channel and overbank areas molded in sand-cement mortar to sheet metal templates up to elevation (el)[1] 275.0 which is sufficient to include all areas that would be affected by a total river discharge of 700,000 cfs.

Structures reproduced in the model include the navigation lock, the spillway, the powerhouse, and the north and south fish ladders. The navigation lock is 26.2128 m (86 ft) wide by 205.74 m (675 ft) long. On the upstream end of the lock is a 182.88-m- (600-ft-) long floating guard wall and on the downstream end there is a 480.06-m- (1,575-ft-) long solid guide wall. The spillway consists of 20 15.24-m- (50-ft-) wide tainter gates and the powerhouse has 20 hydroelectric units. The four powerhouse units on the north end of the powerhouse are not used because in the prototype they are skeleton bays. Skeleton bays are like the other bays except no turbine has been installed.

Construction of the John Day general model was completed in October 1995. Model calibration was accomplished in November 1995, and verification was accomplished in January 1996 by comparing two sets of model current direction and velocity data to prototype current direction and velocity data taken for that purpose.

Scale Relations

The model was built to an undistorted linear scale of 0.3048 m (1 ft) (model) = 24.384 m (80 ft) (prototype). This scale allowed for accurate reproduction of current magnitudes, crosscurrents, and eddies, that would affect navigation in the lower lock approach. Other scale relations resulting from the linear scale are as follows:

[1] All elevation (el) cited herein are in feet referenced to the National Geodetic Vertical Datum (to convert feet to meters, multiply by 0.3048).

Characteristic	Ratio	Scale Relation Model : Prototype
Length	L = L	1:80
Area	$A = L_r^2$	1:6400
Velocity	$V = L_r^{1/2}$	1:8.9
Time	$T = L_r^{1/2}$	1:8:9
Discharge	$Q = L_r^{5/2}$	1:57,243.
Roughness	$N = L_r^{1/6}$	1:2:08

These scale relations allow measurements of current magnitudes, discharge, and water-surface elevations to be quantitatively transferred from the model to the prototype.

Appurtenances

Water is supplied to the model by two 0.2831685 cu m/s (10-cfs) axial flow pumps operating in a circulating system, and discharge is measured at the upstream end of the model by five venturi meters of different sizes to provide for accurate measurement of flow over the range of discharges reproduced. Water-surface elevations are measured in the model at 17 model-gaging stations by means of 17 piezometers located in the model channel and connected to a centrally located gage pit. Adjustable tailgates at the downstream end of the model control water-surface elevations in the portion of the model downstream of the structures. Water-surface elevations upstream of the dam are controlled by manipulating the tainter gates of the spillway and the slide gates of the powerhouse in accordance with operating plans provided by the Portland District. During all experiments, 2.831685 cu m/s (100 cfs) (prototype) is passed through each of the fish ladders. At each fish ladder entrance additional flow ranging from 14.15842 to 28.31685 cu m/s (500 to 1,000 cfs) (prototype) is provided to attract the adults to the entrance. This flow is provided in the model by means of two small centrifugal pumps and the discharge is measured by roto-meters. These pumps also provide flow to the juvenile bypass system chute so its discharge into the tailrace of the powerhouse is accurately modeled.

3 Tests and Results

The primary purpose for the experiments discussed in this report was to determine if the installation of flow deflectors and/or the change in spillway gate patterns for fish migration were the cause of the navigation problems reported by the towing industry.

The secondary objective of these experiments was to identify and document alternatives either structural and/or operational that would improve navigation conditions in the lower lock approach.

Experimental Procedure

A representative selection of riverflows and operational conditions was used for testing based on discussions held between representatives of the Portland District, Columbia River Towing Association, and ERDC. Table 1 lists the conditions that were used for these experiments. For each of the conditions listed in Table 1, current direction and velocity data and navigation tests were conducted with and without flow deflectors installed on the spillway.

Table 1
Experiment Conditions

Total Discharge (cfs)[1]	Powerhouse Discharge (cfs)	Spillway Discharge (cfs)	Spill Pattern (year)
325,000	250,000	75,000	1997
340,000	255,000	85,000	1997
350,000	250,000	100,000	1997
325,000	250,000	75,000	1998
340,000	255,000	85,000	1998
350,000	250,000	100,000	1998
225,000	90,000	135,000	1999
225,000	157,500	67,500	1999
325,000	175,000	150,000	1999
350,000	200,000	150,000	1999
425,000	250,000	175,000	1999

[1] To convert feet to meters, multiply by 0.3048.

Tests were conducted by introducing the proper discharge into the model and maintaining the proper upper pool and tailwater elevations for a given discharge. The upper pool elevation was maintained at el 264.0 by operating the powerhouse and spillway in accordance with the operational schedule furnished by the Portland District. The lower pool elevation was maintained by manipulating the tailgate until the water-surface elevation matched the tailwater rating curve provided by the district. Operational details for each of the conditions in Table 1 are shown on the current direction and velocity plates.

Current direction and velocity (CDV) data were collected by tracking the path of cylindrical floats submerged to a depth of 4.2672 m (14 ft) (prototype) as they floated through the test section of the model. The data were collected using a video tracking system (VTS) that traces the path of a moving object by digitizing frames of video. A radio-controlled model towboat and barge were used to determine and demonstrate the effects of currents on tows approaching and leaving the lock. The speed and the rudders of the tow were remote-controlled and the towboat could be operated in forward and reverse at speeds comparable to typical tows on the Columbia River. The model boat used for evaluation of navigation conditions represented a five-barge tow. The barge flotilla, suggested by representatives of the Columbia River Towing Association as a typical arrangement, was 25.6032 m (84 ft) wide by 198.12 m (650 ft) long. The four lead barges drafted 3.9624 m (13 ft) and the barge on the starboard side of the towboat drafted 3.048 m (10 ft). The VTS was used to track the model vessel during all experiments, and plots of these tracks were used to aid in the evaluation of navigation conditions.

1997 Spill Pattern, No Flow Deflectors

Current directions and velocities

Current direction and velocity data for total river discharges of 9,202.975; 9,627.728; and 9,910.896 cu m/s (325,000, 340,000, and 350,000 cfs) and no flow deflectors installed on the spillway are shown in Plates 1-3. With all three flow conditions there is a large clockwise rotating eddy that forms in the entrance to the lower lock approach. Velocities in the eddy are less than 0.1524 m/s (0.5 fps) with all three flows. Downstream of the end of the guide wall, flow from the spillway enters the navigation channel at an angle. The angle, relative to the guide wall, and velocity of the flow as it enters the navigation channel approximately 106.68 m (350 ft) downstream of the guide wall ranges from about 30 deg and 0.27432 m/s (0.9 fps) with the 9,202.975 cu m/s (325,000 cfs) flow to about 27 deg and 0.51816 m/s (1.7 fps) with the 9,910.896 cu m/s (350,000 cfs) flow. Approximately 304.8 m (1,000 ft) downstream of the end of the guide wall, the angle and velocity of the flow ranges from 12 deg and 0.82296 m/s (2.7 fps) with the 9,202.975 cu m/s (325,000 cfs) flow to 11 deg and 0.82296 m/s (2.7 fps) with the 9,910.896 cu m/s (350,000 cfs) flow.

Navigation conditions

Tow paths of the model tow entering and exiting the lower lock approach with riverflows of 9,202.975; 9,627.728; and 9,910.896 cu m/s (325,000, 340,000, and 350,000 cfs) and no flow deflectors installed on the spillway are shown in Plates 4-9. Upbound tows approaching the lower lock approach were required to take a slight set toward the guide wall as they approached the entrance to the lock approach. The set was not severe and upbound tows were able to move slowly into the approach without any danger of hitting the end of the wall or being pushed into the right descending bank. Downbound tows were required to take a riverward set. However, they were able to move slowly out of the approach with no danger of being pushed into the right descending bank.

1997 Spill Pattern, Flow Deflectors Installed in Spillway (Bays 2–19)

Current directions and velocities

Current direction and velocity data for total river discharges of 9,202.975; 9,627.728; and 9,910.896 cu m/s (325,000, 340,000, and 350,000 cfs) and flow deflectors installed in spillway bays 2–19 of the spillway are shown in Plates 10-12. With all three flow conditions there is a large clockwise rotating eddy that forms in the entrance to the lower lock approach. Velocities in the eddy are less than 0.1524 m/s (0.5 fps) with the 9,202.975 and 9,627.728 cu m/s (325,000 and 340,000 cfs) flows and are a maximum of 0.24384 m/s (0.8 fps) with the 9,910.896 cu m/s (350,000 cfs) flow. Downstream of the end of the guide wall, flow from the spillway enters the navigation channel at an angle. Approximately 106.68 m (350 ft) downstream of the guide wall the angle and velocity of flow ranges from about 26 deg and 0.33528 m/s (1.1 fps) with the 9,202.975 cu m/s (325,000 cfs) flow to about 26 deg and 0.51816 m/s (1.7 fps) with the 9,910.896 cu m/s (350,000 cfs) flow. Approximately 304.8 m (1,000 ft) downstream of the end of the guide wall, the angle and velocity of the flow ranges from 14 deg and 0.82296 m/s (2.7 fps) with the 9,202.975 cu m/s (325,000 cfs) flow to 14 deg and 0.88392 m/s (2.9 fps) with the 9,910.896 cu m/s (350,000 cfs) flow.

Navigation conditions

Tow paths of the model tow entering and exiting the lower lock approach with riverflows of 9,202.975; 9,627.728; and 9,910.896 cu m/s (325,000, 340,000, and 350,000 cfs) and flow deflectors installed on spillway bays 2–19 are shown in Plates 13–18. Experiments with the model tow entering and exiting the lower lock approach did not reveal any significant difference in the navigation conditions as compared with the same flow conditions and no deflectors installed. Upbound tows approaching the lower lock were required to take a slight set toward the guide wall as they approached the entrance to the lock approach. The set was not severe and upbound tows were able to move slowly into the approach without any danger of hitting the end of the wall or being pushed into the right descending bank. Downbound tows were required to take a riverward set. However, they were

able to move slowly out of the approach with no danger of being pushed into the right descending bank.

1998 Spill Pattern, No Flow Deflectors

Current directions and velocities

Current direction and velocity data for total river discharges of 9,202.975; 9,627.728; and 9,910.896 cu m/s (325,000, 340,000, and 350,00 cfs) and no flow deflectors installed on the spillway are shown in Plates 19–21. With all three flow conditions there is a large clockwise rotating eddy that forms in the entrance to the lower lock approach. Maximum velocities in the eddy range from 0.01699011 m/s (0.6 fps) with the 9,202.975 cu m/s (325,000 cfs) flow to 0.33528 m/s (1.1 fps) with the 9,627.728 cu m/s (340,000 cfs) flow. Downstream of the end of the guide wall, flow from the spillway enters the navigation channel at an angle. The angle, and velocity of the currents approximately 106.68 m (350 ft) downstream of the guide wall ranges from about 19 deg and 0.64008 m/s (2.1 fps) with the 9,202.975 cu m/s (325,000 cfs) flow to about 21 deg and 0.70104 m/s (2.3 fps) with the 9,910.896 cu m/s (350,000 cfs) flow. Approximately 304.8 m (1,000 ft) downstream of the end of the guide wall, the angle and velocity of the flow ranges from 7 deg and 1.24968 m/s (4.1 fps) with the 9202.975 cu m/s (325,000 cfs) flow to 11 deg and 1.03632 m/s (3.4 fps) with the 9910.896 cu m/s (350,000 cfs) flow.

Navigation conditions

Tow paths of the model tow entering and exiting the lower lock approach with river flows of 9,202.975; 9,627.728; and 9,910.896 cu m/s (325,000, 340,000, and 350,000 cfs) are shown in Plates 22–27. Experiments with the model tow entering and exiting the lower lock approach indicated navigation conditions are not significantly different than with the 1997 spill pattern and no flow deflectors. Upbound tows approaching the lower lock approach were required to take a slight set toward the guide wall as they approached the entrance to the lock approach. The set was not severe and upbound tows were able to move slowly into the approach without any danger of hitting the end of the wall or being pushed into the right descending bank. Downbound tows were required to take a riverward set. However, they were able to move slowly out of the approach with no danger of being pushed into the right descending bank.

1998 Spill Pattern, Flow Deflectors Installed in Spillway (Bays 2–19)

Current directions and velocities

Current direction and velocity data for total river discharges of 9,202.975; 9,627.728; and 9910.896 cu m/s (325,000, 340,000, and 350,000 cfs) and flow deflectors installed on the spillway bays are shown in Plates 28-30. With all three flow conditions there is a large clockwise rotating eddy that forms in the entrance to the lower lock approach. Maximum velocities in the eddy range from 0.027432 m/s (0.9 fps) with the 9,202.975 cu m/s (325,000 cfs) flow to 0.39624 m/s (1.3 fps) with the 340,000 cfs flow. Downstream of the end of the guide wall, flow from the spillway enters the navigation channel at an angle. The angle, and velocity of the currents approximately 106.68 m (350 ft) downstream of the guide wall ranges from about 20 deg and 0.79248 m/s (2.6 fps) with the 9,627.728 cu m/s (340,000 cfs) flow to about 27 deg and 0.67056 m/s (2.2 fps) with the 9,202.975 cu m/s (325,000 cfs) flow. Approximately 304.8 m (1,000 ft) downstream of the end of the guide wall, the angle and velocity of the flow ranges from 12 deg and 1.03632 m/s (3.4 fps) with the 9,910.896 cu m/s (350,000 cfs) flow to 13 deg and 1.12776 m/s (3.7 fps) with the 9,202.975 cu m/s (325,000 cfs) flow.

Navigation conditions

Tow paths of the model tow entering and exiting the lower lock approach with river flows of 9,202.975; 9,627.728; and 9,910.896 cu m/s (325,000, 340,000, and 350,000 cfs) are shown in Plates 31-36. Experiments with the model tow entering and exiting the lower lock approach indicated navigation conditions are not significantly different than with the 1997 spill pattern and no flow deflectors. Upbound tows approaching the lower lock approach were required to take a slight set toward the guide wall as they approached the entrance to the lock approach. The set was not severe, and upbound tows were able to move slowly into the approach without any danger of hitting the end of the wall or being pushed into the right descending bank. Downbound tows were required to take a riverward set. However, they were able to move slowly out of the approach with no danger of being pushed into the right descending bank.

1999 Spill Pattern, Flow Deflectors Installed in Spillway (Bays 1–20)

Current directions and velocities

Current direction and velocity data for total river discharges of 6,371.29; 9,202.975; 9,910.896; and 12,037.66 cu m/s (225,000, 325,000, 350,000, and 425,000 cfs) and flow deflectors installed in spillway bays 1–20 are shown in Plates 37–41. The 6,371.29 cu m/s (225,000 cfs) total river discharge was tested with two flow distributions, 1,902.892 cu m/s (67,200 cfs) through the spillway (Plate 37) and 3,805.784 cu m/s (134,400 cfs) through the spillway (Plate 38).

With all five flow conditions there is a large clockwise rotating eddy that forms in the entrance to the lower lock approach. Maximum velocities in the eddy range from 0.24384 m/s (0.8 fps) with the 6,371.29 cu m/s (225,000 cfs) flow to 0.36576 m/s (1.2 fps) with the 12,034.66 cu m/s (425,000 cfs) flow. Downstream of the end of the guide wall, flow from the spillway enters the navigation channel at an angle. The angle, relative to the guide wall, and velocity of the flow as it enters the navigation channel approximately 106.68 m (350 ft) downstream of the guide wall ranges from about 26 deg and 0.70104 m/s (2.3 fps) with the 6,371.29 cu m/s (225,000 cfs) flow to about 35 deg and 0.3048 m/s (1.0 fps) with the 9,910.896 cu m/s (350,000 cfs) flow. Approximately 304.8 m (1,000 ft) downstream of the end of the guide wall, the angle and velocity of the flow ranges from 10 deg and 1.2192 m/s (4.0 fps) with the 6,371.29 cu m/s (225,000 cfs) flow to 14 deg and 1.03632 m/s (3.4 fps) with the 12,034.66 cu m/s (425,000 cfs) flow.

Navigation conditions

Tow paths of the model tow entering and exiting the lower lock approach with river flows of 6,371.29; 9,202.975; 9,910.896; and 12,037.66 cu m/s (225,000, 325,000, 350,000, and 425,000 cfs) are shown in Plates 42–51. Experiments with the model tow entering and exiting the lower lock approach indicated navigation conditions are not significantly different than with the 1998 spill pattern. Upbound tows approaching the lower lock approach were required to take a slight set toward the guide wall as they approached the entrance to the lock approach. The set was not severe and upbound tows were able to move slowly into the approach without any danger of hitting the end of the wall or being pushed into the right descending bank. Downbound tows were required to take a riverward set. However, they were able to move slowly out of the approach with no danger of being pushed into the right descending bank.

Table 2 is a summary of the angle and velocity of the flow entering the navigation channel 106.68 m (350 ft) downstream of the guide wall with each of the conditions tested. Figures 5 and 6 are graphical representations of the data contained in Table 2. Figure 5 is a plot of velocity entering the channel 106.68 m (350 ft) downstream of the end of the guide wall versus discharge. Figure 6 is the same type of plot showing angle of the currents versus discharge. Table 3 is the same type of summary for flow entering the channel 304.8 m (1,000 ft) downstream of the end of the wall and Figures 7 and 8 are graphical representations of the data.

Table 2 and Figure 5 show the addition of flow deflectors with either the 1997 or 1998 spill pattern did not significantly change the velocities entering the navigation channel 106.68 m (350 ft) downstream of the guide wall. However, Figure 5 clearly shows that changing spill patterns from 1997 to 1998 did cause an increase in the velocity. Also Figure 6 shows that the angle of the currents entering the channel is inversely proportional to the velocity. Angles are smaller with the1998 pattern than with the 1997 pattern. With the 1999 pattern and flow deflectors installed, the velocity decreases as the discharge increases until a river flow of about 9,910.896 cu m/s (350,000 cfs). Then as the flow increases to 12,034.66 cu m/s (425,000 cfs), the velocity rapidly increases again. As with the other patterns the angle is inversely proportional to the velocity.

Table 2
Angle and Velocity of Currents 106.68 m (350 ft) Downstream of Guide Wall

Spill Pattern (year)	Deflectors	Total Discharge cu m/s (cfs)	Angle (deg)	Velocity m/s (fps)
1997	None	9202.975 (325,000)	30	0.27432 (0.9)
1997	None	9627.728 (340,000)	26	0.48768 (1.6)
1997	None	9910.896 (350,000)	27	0.51816 (1.7)
1997	2 – 19	9202.975 (325,000)	27	0.33528 (1.1)
1997	2 – 19	9627.728 (340,000)	29	0.4572 (1.5)
1997	2 – 19	9910.896 (350,000)	26	0.51816 (1.7)
1998	None	9202.975 (325,000)	19	0.64008 (2.1)
1998	None	9627.728 (340,000)	17	0.70104 (2.3)
1998	None	9910.896 (350,000)	21	0.70104 (2.3)
1998	2 - 19	9202.975 (325,000)	27	0.67056 (2.2)
1998	2 – 19	9627.728 (340,000)	20	0.79248 (2.6)
1998	2 – 19	9910.896 (350,000)	21	0.6096 (2.0)
1999	1 – 20	6371.29 (225,000)	26	0.70104 (2.3)
1999	1 – 20	6371.29 (225,000)	14	0.79248 (2.6)
1999	1 – 20	9202.975 (325,000)	17	0.64008 (2.1)
1999	1 – 20	9910.896 (350,000)	35	0.48768 (1.6)
1999	1 – 20	12034.66 (425,000)	27	0.73152 (2.4)

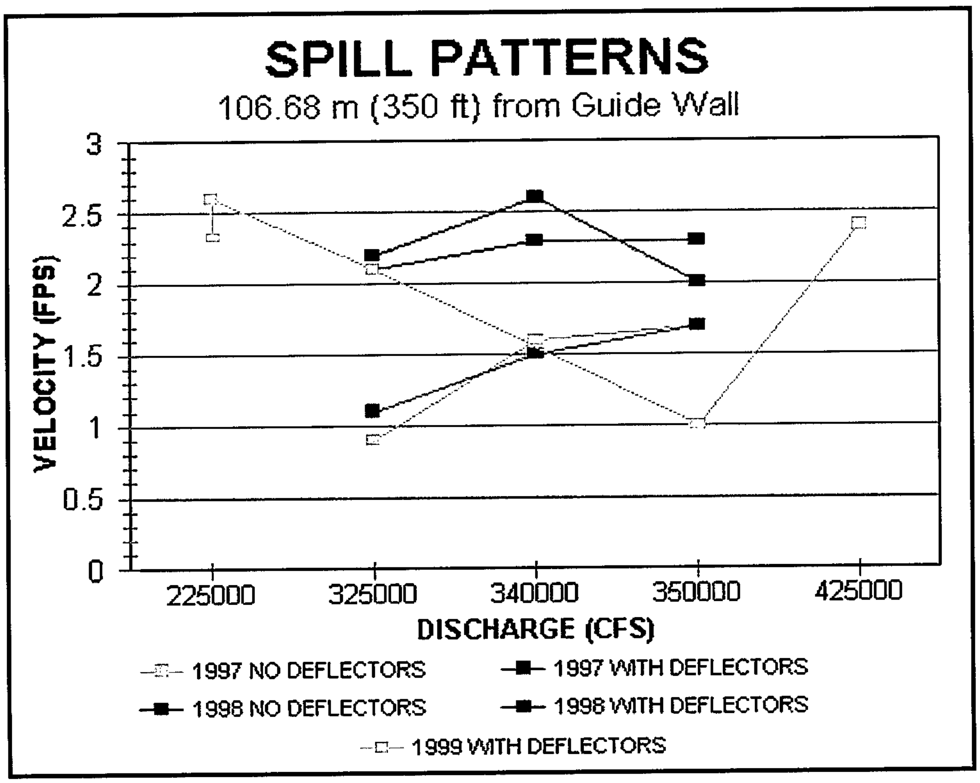


Figure 5. Velocity versus discharge plot of flow entering navigation channel 106.68 m (350 ft) downstream of guide wall (discharge is in cubic feet per second, to convert to cubic meters per second, multiply by 0.02831)

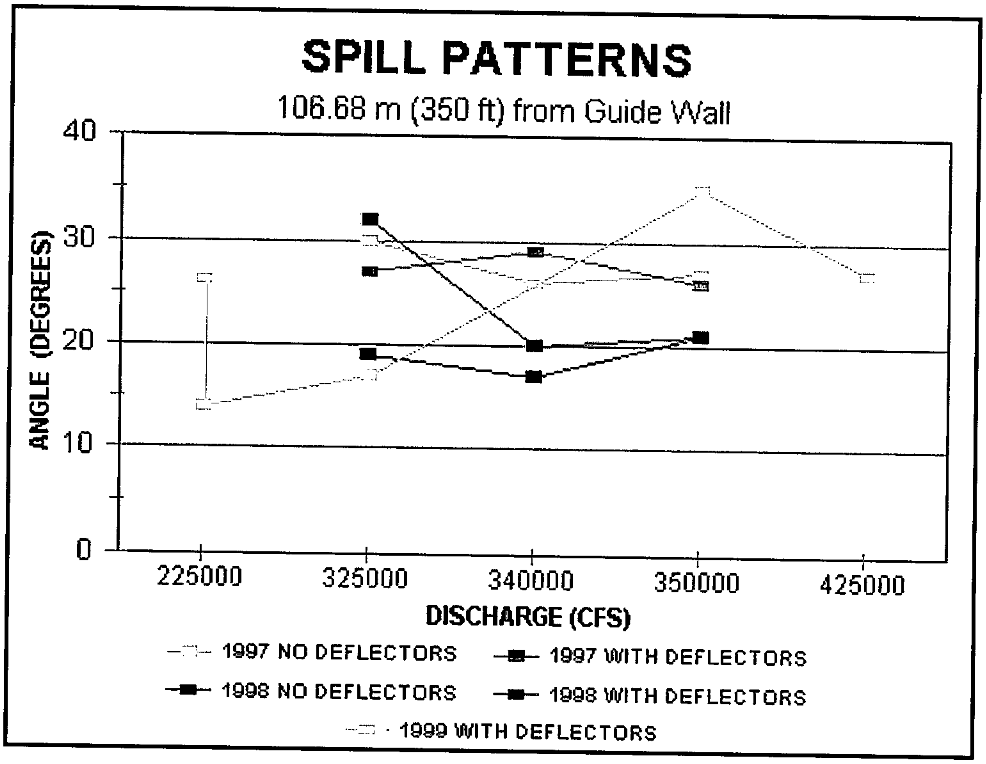


Figure 6. Angle versus discharge plot of flow entering navigation channel 106.68 m (350 ft) downstream of guide wall

Table 3
Angle and Velocity of Currents 304.8 m (1,000 ft) Downstream of Guide Wall

Spill Pattern (year)	Deflectors	Total Discharge cu m/s (cfs)	Angle (deg)	Velocity m/s (fps)
1997	None	9202.975 (325,000)	12	0.82296 (2.7)
1997	None	9627.728 (340,000)	12	0.79248 (2.6)
1997	None	9910.896 (350,000)	11	0.82296 (2.7)
1997	2 – 19	9202.975 (325,000)	14	0.82296 (2.7)
1997	2 - 19	9627.728 (340,000)	16	0.85344 (2.8)
1997	2 – 19	9910.896 (350,000)	14	0.88392 (2.9)
1998	None	9202.975 (325,000)	7	1.24968 (4.1)
1998	None	9627.728 (340,000)	12	1.03632 (3.4)
1998	None	9910.896 (350,000)	11	1.03632 (3.4)
1998	2 – 19	9202.975 (325,000)	13	1.12776 (3.7)
1998	2 – 19	9627.728 (340,000)	12	1.31064 (4.3)
1998	2 – 19	9910.896 (350,000)	12	1.03632 (3.4)
1999	1 – 20	6371.29 (225,000)	13	1.03632 (3.4)
1999	1 – 20	6371.29 (225,000)	10	1.2192 (4.0)
1999	1 – 20	9202.975 (325,000)	11	0.9144 (3.0)
1999	1 – 20	9910.896 (350,000)	5	1.03632 (3.4)
1999	1 – 20	12034.66 (425,000)	14	1.03632 (3.4)

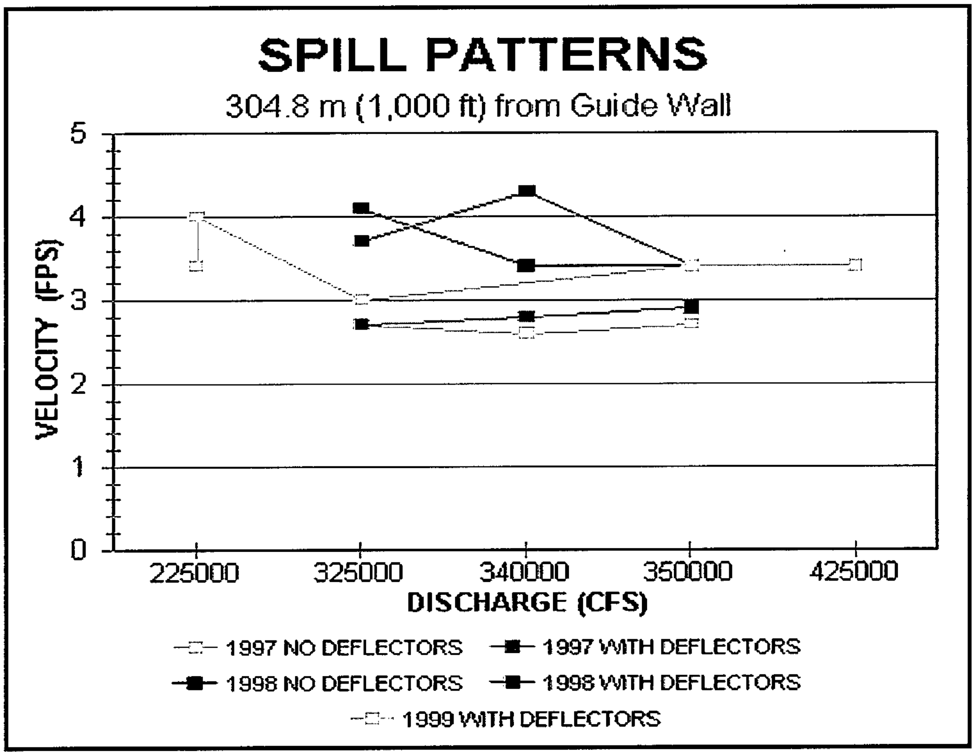


Figure 7. Velocity versus discharge plot of flow entering navigation channel 304.8 m (1,000 ft) downstream of guide wall

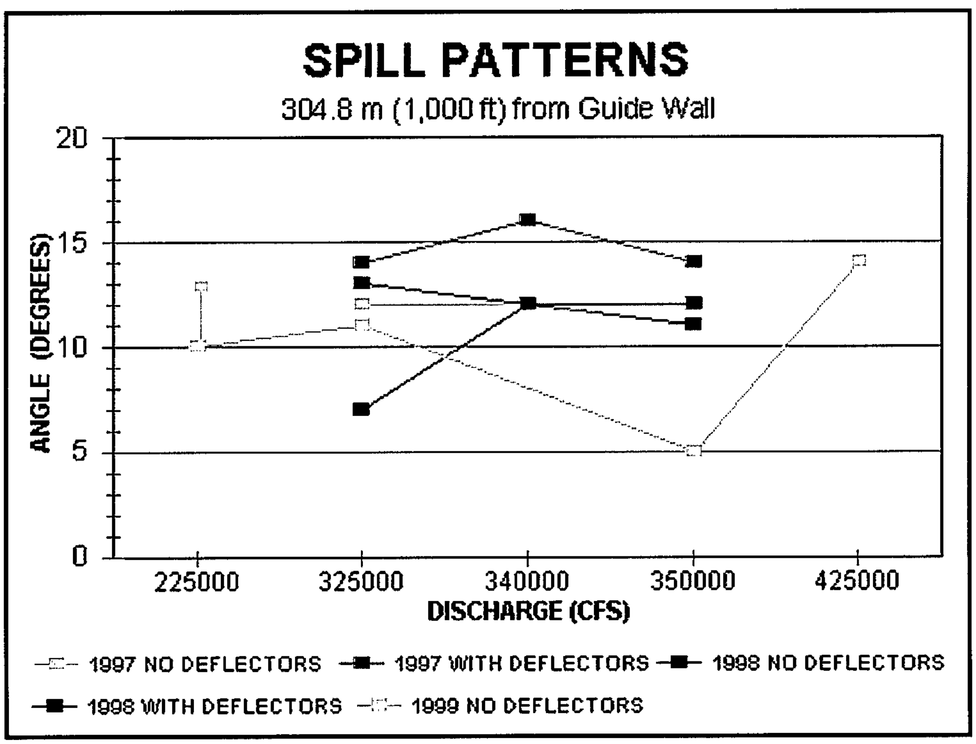


Figure 8. Angle versus discharge plot of flow entering navigation channel 304.8 m (1,000 ft) downstream of guide wall

4 Prototype Tests and Results

After completion of the experiments previously discussed, representatives of the Columbia River Towing Association were invited to ERDC. The current direction and velocity data and tow path data were presented and operation of the model tow was demonstrated. Operators from the association were allowed to pilot the model tow with some of the conditions tested. The consensus of the group was that the evaluation of conditions in the model was appropriate, but the model did not seem to be accurately representing the prototype. Therefore, a plan was developed to perform a model to prototype comparison. The first step would be to compare the model bed geometry to a very recent hydrographic survey. The next step would be to track prototype vessels entering and exiting the lower lock approach and make a comparison to the model data. The final step would be to take prototype current direction and magnitude data to compare to model data. At the time of the writing of this report, the hydrographic survey and prototype velocity data collection had not been completed.

A team from CHL traveled to John Day Lock and Dam to track vessels entering and exiting the lower lock approach. The tracking was accomplished using the Global Positioning System (GPS) in differential mode (DGPS). The team installed a GPS receiver over a known survey point on the lock. This receiver was used as the base station and differential corrections necessary for sub-meter accuracy for the mobile units were obtained from this receiver. The team boarded seven vessels during a 1-week exercise. Two GPS receivers were mounted on each of the vessels boarded, one near the stern and one near the bow. These mobile units were surveyed so their positions relative to the center line and bow of the tow were known. Three of the vessels were upbound and entered the lock and four of the vessels exited the lock in the downbound direction. The tow paths of the vessels tracked with DGPS are shown on Plates 52–58. Each tow path plate contains information describing the spillway and powerhouse operation during the voyage. Table 4 contains pertinent information about the vessels that were tracked.

Table 4
Prototype Vessel Parameters

Vessel Name	Towing Company	Tow H.P.	Vessel Length/ Width/Draft m (ft)	Number of Barges/Draft m (ft)	Overall Length/Width m (ft)
Outlaw	Tidewater	3,000	31.7/9.5/2.9 (104/31/9.5)	3/0.9144 (3) 1/2.1336 (7)	184.7/25.6 (606/84)
Katherine B	Bernett	1,600	33.5/6.7/2.7 (110/22/9)	3/2.1336 (7) 1/3.048 (10)	194.5/25.6 (638/84)
Challenger	Tidewater	3,000	33.8/9.9/3.4 (111/32.5/11)	1/0.9144 (3) 1/4.20624 (13.8) 1/2.7432 (9)	191.7/25.6 (629/84)
Mary B	Bernett	1,500	19.8/7.0/1.8 (65/23/6)	1/0.9144 (3)	59.7/12.2 (196/40)
Chief	Tidewater	4,000	37.2/12.2/3.2 (122/40/10.5)	1/4.1148 (13.5)	120.7/29.6 (396/84)
Clarkston	Foss	3,000	25.9/8.5/3.2 (85/28/10.5)	1/3.2004 (10.5) 1/1.8288 (6) 2/2.4384 (8)	180.7/25.6 (593/84)
Outlaw	Tidewater	3,000	31.7/9.5/3.0 (104/31/10)	2/3.9624 (13) 2/2.1336 (7) 1/4.2672 (14)	180.4/25.6 (592/84)

Analysis of the prototype data indicated there is a strong correlation between the model and the prototype. The angle of the tows entering and exiting the lock approach correspond closely to the model data even though the model was not set to exactly represent the prototype. For example, if you compare Plate 22, that is model data collected with the 1998 spill pattern and a total river discharge of 9,202.975 cu m/s (325,000 cfs), to Plate 52, that is prototype data with similar discharge and spillway setup, the angle the tow must maintain while approaching the lock is very near the same. This is true even though the model setup and tow configuration is slightly different. This comparison suggests that the model is adequately reproducing conditions in the prototype. Furthermore, comments from the pilots during the seven voyages confirm that during these experiments no significant navigation problems existed. Therefore, further investigations into the reason for the pilots' concerns and reports of incidents at John Day need to be conducted. Comparison of prototype bathymetry to model bathymetry will be accomplished in the near future and could explain some of the complaints. Consequently, the district should consider model experiments to investigate structural or operational measures that could be used to reduce the angle of the current entering the navigation channel downstream of the lock wall, thereby, reducing the tendency for tows to be pushed toward the north shore.

5 Summary and Conclusions

Based on the model and prototype experiments described above, the following conclusions were reached:

a. Installation of flow deflectors on the spillway of John Day did not significantly change velocities or current directions in the lower lock approach.

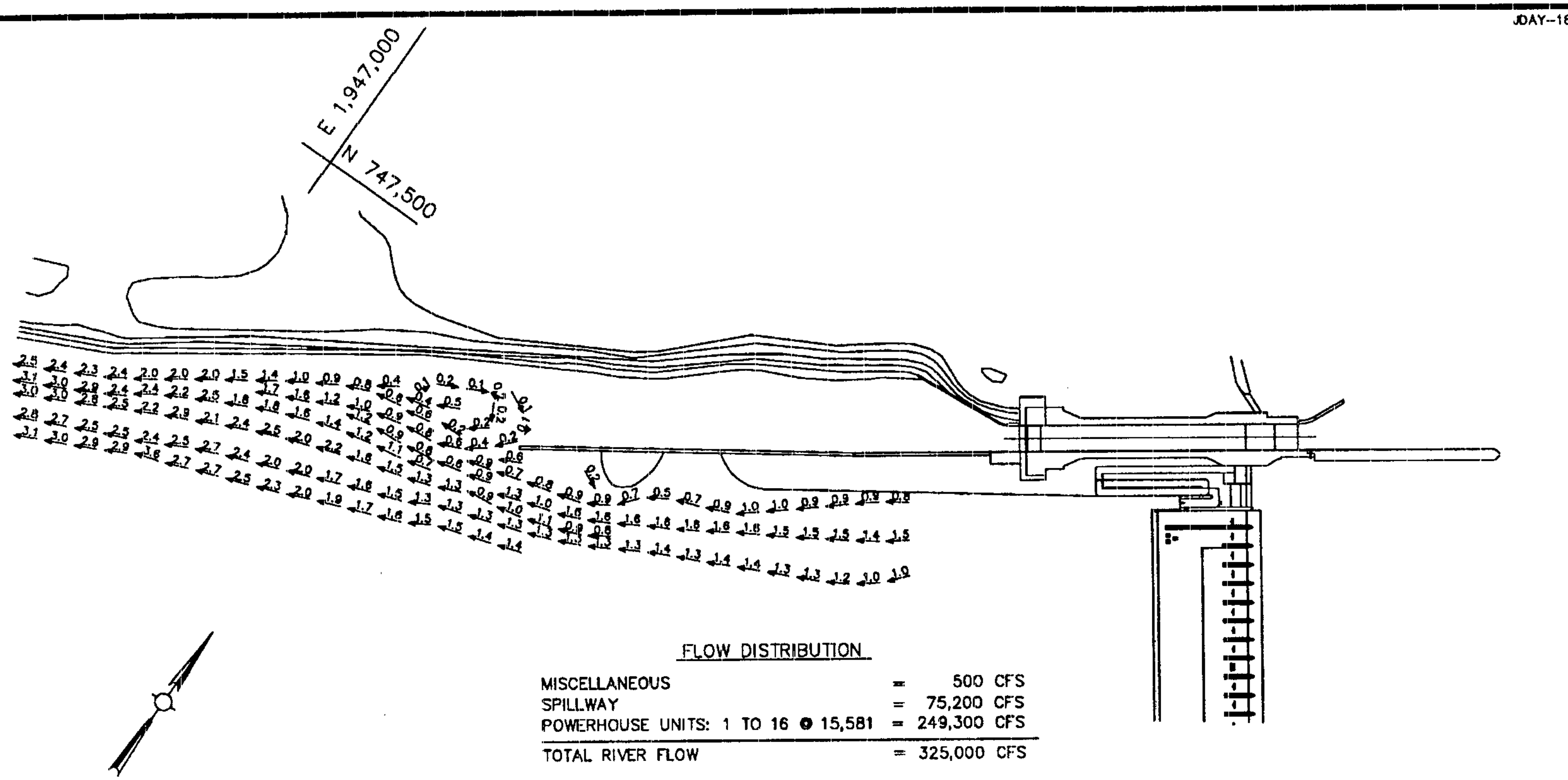
b. Changing the spillway from the 1997 to the 1999 spill patterns caused the velocity of the current entering the channel downstream of the guide wall to increase.

c. Comparisons of prototype tow tracks taken with DGPS to model tow tracks taken under similar conditions indicate the model is adequately reproducing conditions in the prototype.

d. Model experiments conducted with the radio-controlled towboat indicate that navigation conditions for tows entering and exiting the lower lock approach are satisfactory with all flows tested.

e. Model bathymetry should be compared to recent prototype hydrographic survey to insure the model bed is accurately reproducing the existing river conditions

f. Model experiments should be conducted to investigate measures, either operational or structural, that can be taken to reduce the set and the amount of maneuvering required for tows to enter or exit the lower lock approach.



FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	75,200 CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,581	=	249,300 CFS
TOTAL RIVER FLOW	=	325,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	4.5	4.5	3

SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

LEGEND

1.0 VELOCITY IN FEET PER SECOND (To convert feet per second to meters per second, multiply by 0.3048)

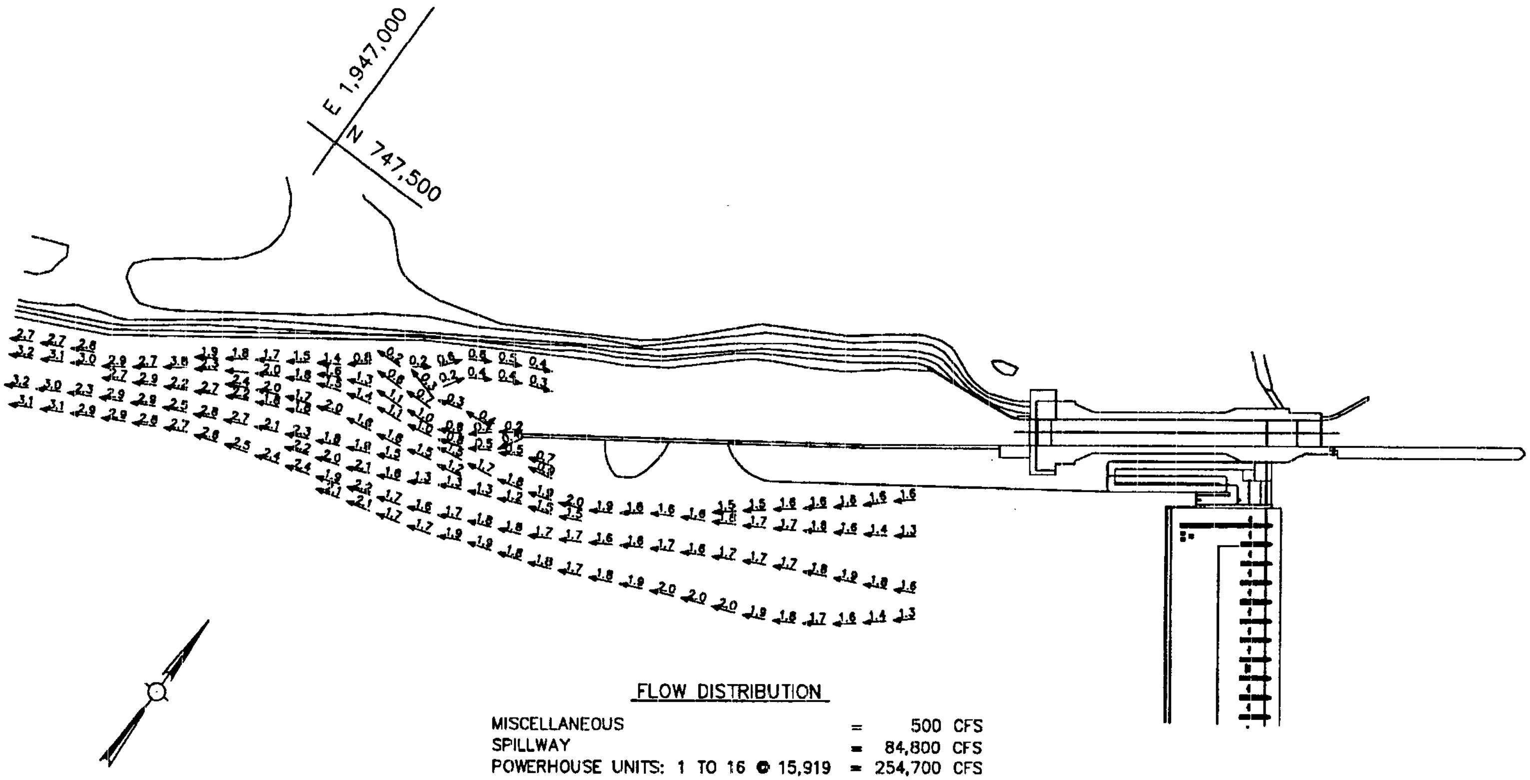
• INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NO DEFLECTORS IN

VELOCITIES AND CURRENT DIRECTIONS

1997 SPILL PATTERN
VELOCITIES AT 14 FT
DISCHARGE: 325,000 CFS
LOWER POOL EL.163.7 FT



FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	84,800 CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,919	=	254,700 CFS
TOTAL RIVER FLOW	=	340,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	2	2	2	2	3	2	2	3	2	3	2	3	2	3	2	3	3	4.5	4.5	3

SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

LEGEND

1.0 VELOCITY IN FEET PER SECOND (To convert feet per second to meters per second, multiply by 0.3048)

• INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NO DEFLECTORS IN

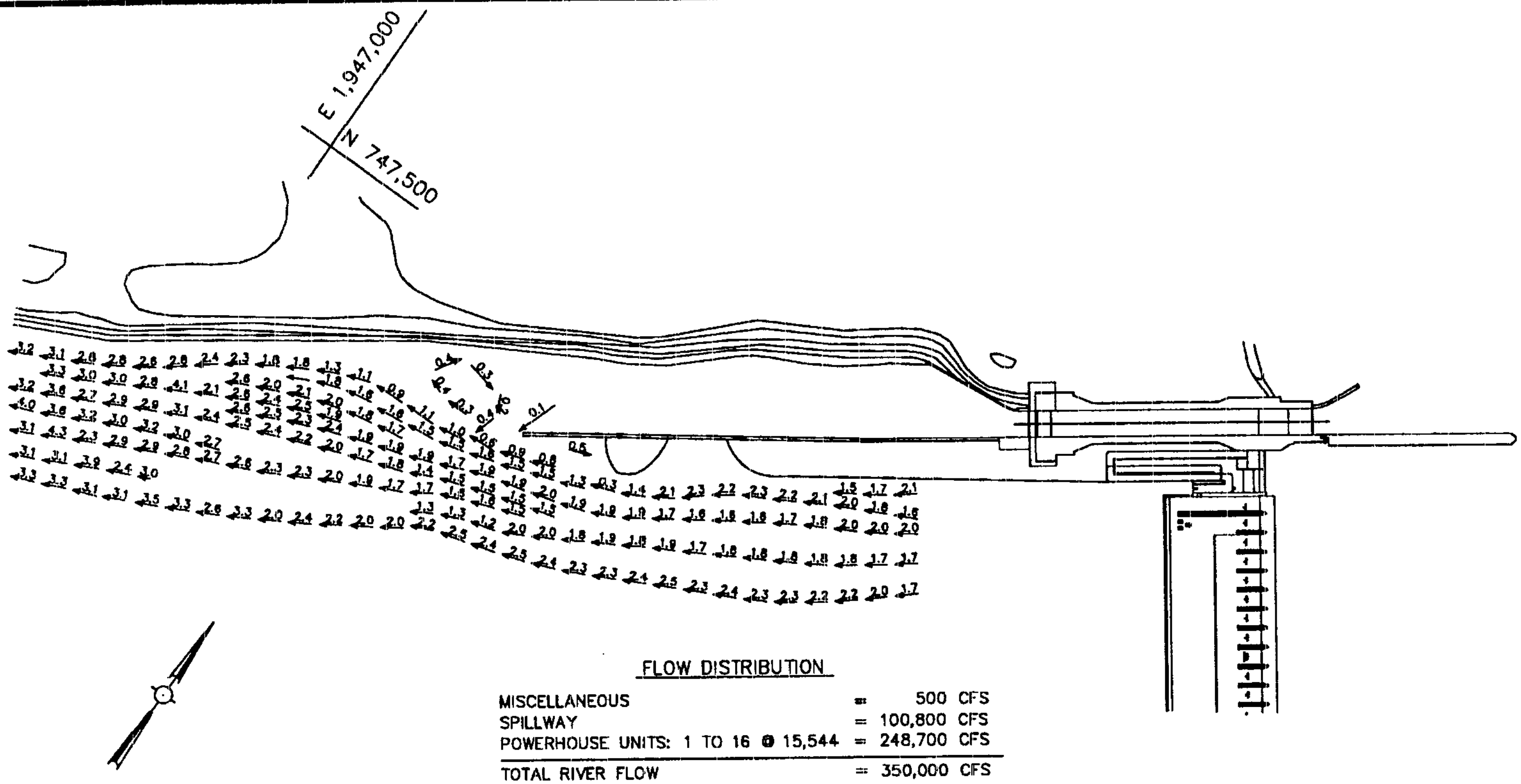
VELOCITIES AND CURRENT DIRECTIONS

1997 SPILL PATTERN

VELOCITIES AT 14 FT

DISCHARGE: 340,000 CFS

LOWER POOL EL: 164.1 FT



FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	100,800 CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,544	=	248,700 CFS
TOTAL RIVER FLOW	=	350,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4.5	4.5	3

SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

LEGEND

1.0 VELOCITY IN FEET PER SECOND
(To convert feet per second to meters per second, multiply by 0.3048)

• INDICATES SPILLWAY GATES CLOSED

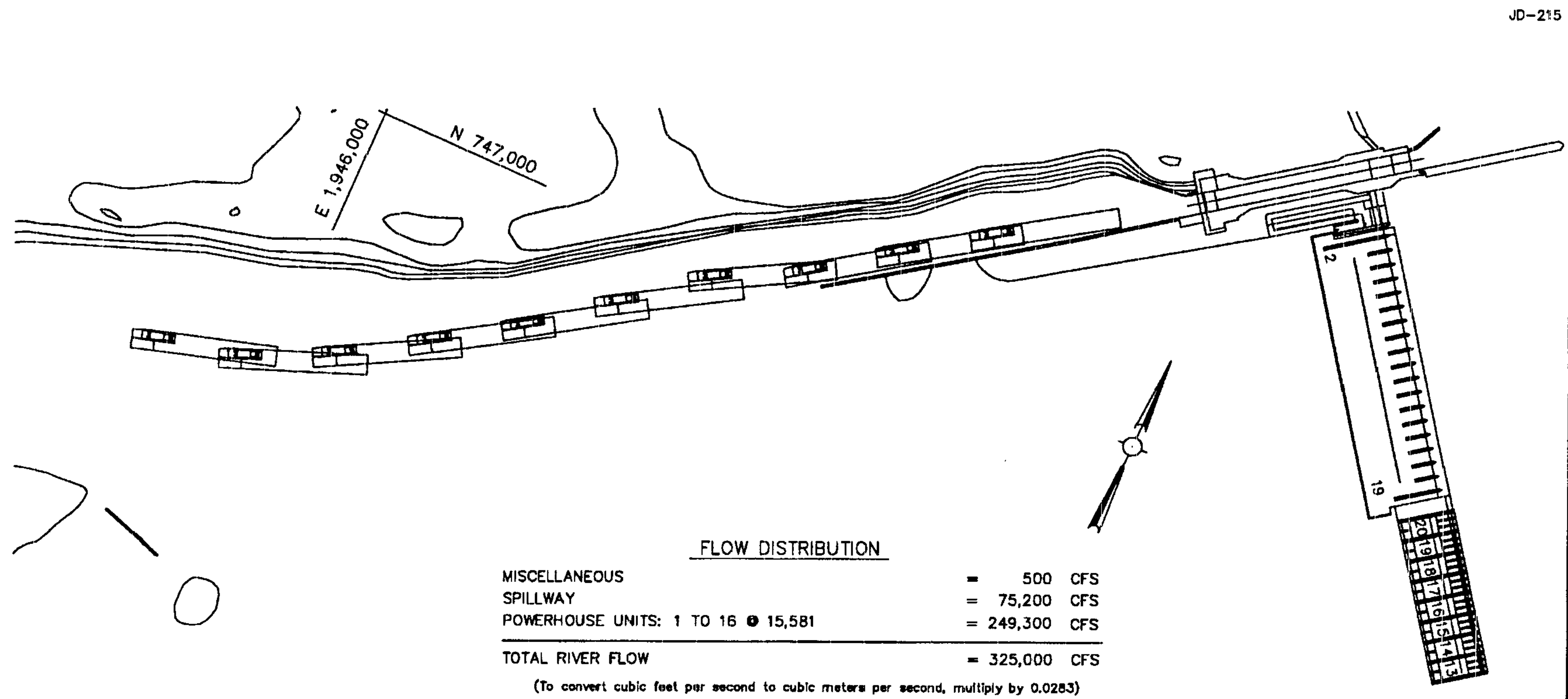
NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NO DEFLECTORS IN

VELOCITIES AND CURRENT DIRECTIONS

1997 SPILL PATTERN
VELOCITIES AT 14 FT

DISCHARGE: 350,000 CFS
LOWER POOL EL: 164.4 FT



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 75,200	CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,581	= 249,300	CFS
TOTAL RIVER FLOW	= 325,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	4.5	4.5	3

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NO DEFLECTORS IN

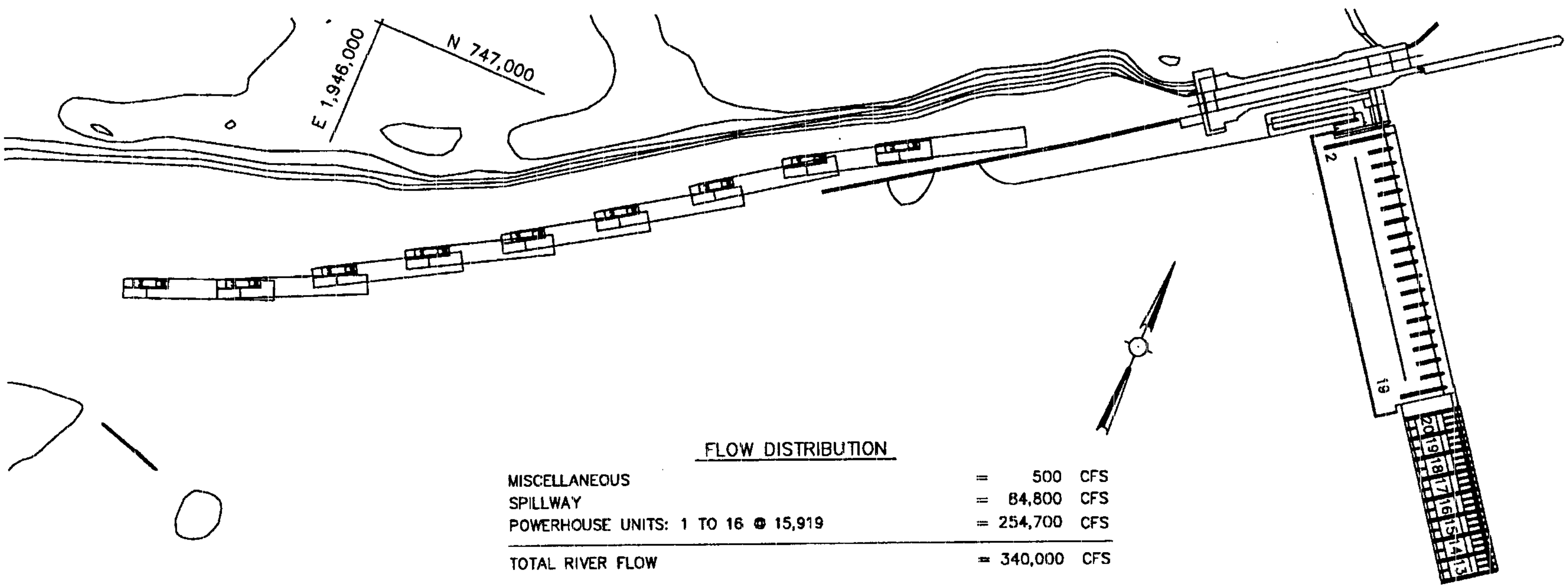
SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
ENTERING LOCK
1997 SPILL PATTERN
DISCHARGE: 325,000 CFS
LOWER POOL EL: 163.7 FT



FLOW DISTRIBUTION

MISCELLANEOUS	=	500	CFS
SPILLWAY	=	84,800	CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,919	=	254,700	CFS
TOTAL RIVER FLOW	=	340,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	2	2	2	2	3	2	2	3	2	3	2	3	2	3	2	3	3	4.5	4.5	3

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NO DEFLECTORS IN

SCALES IN FEET

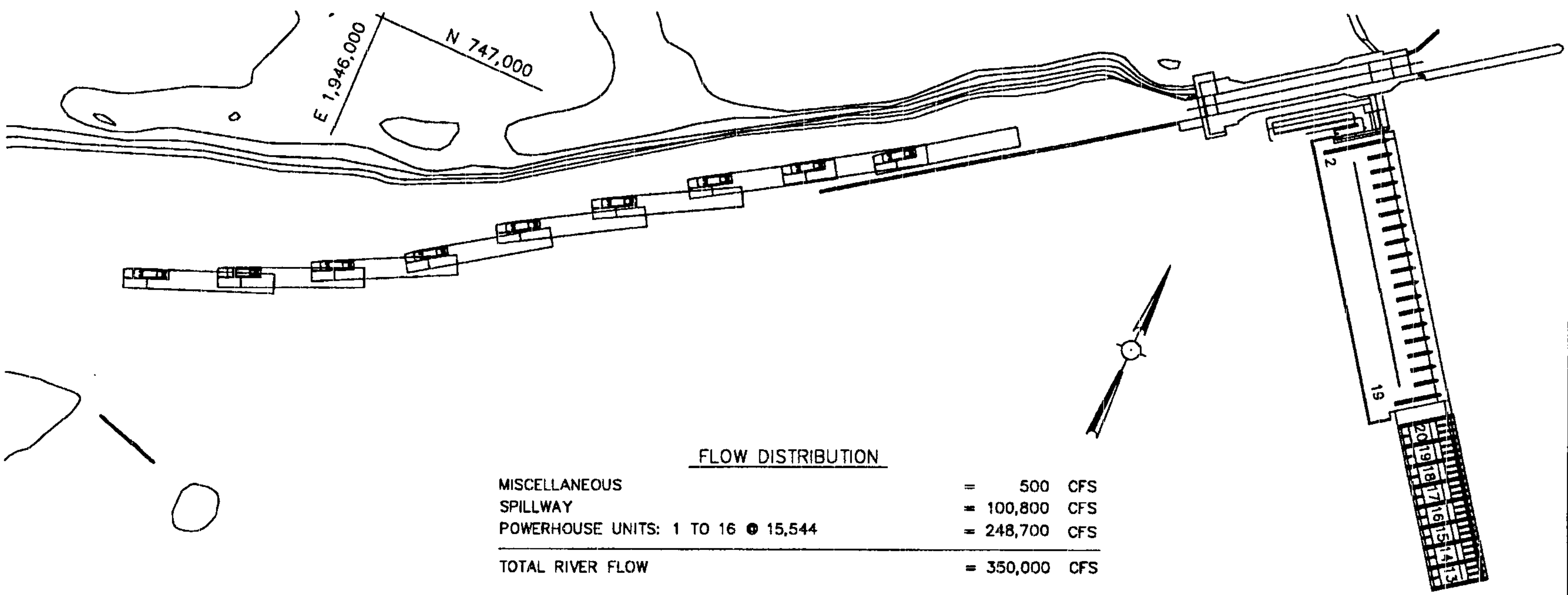
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
ENTERING LOCK
1997 SPILL PATTERN
DISCHARGE: 340,000 CFS
LOWER POOL EL: 164.1 FT

JD--206



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 100,800	CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,544	= 248,700	CFS
TOTAL RIVER FLOW	= 350,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4.5	4.5	3

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NO DEFLECTORS IN

SCALES IN FEET

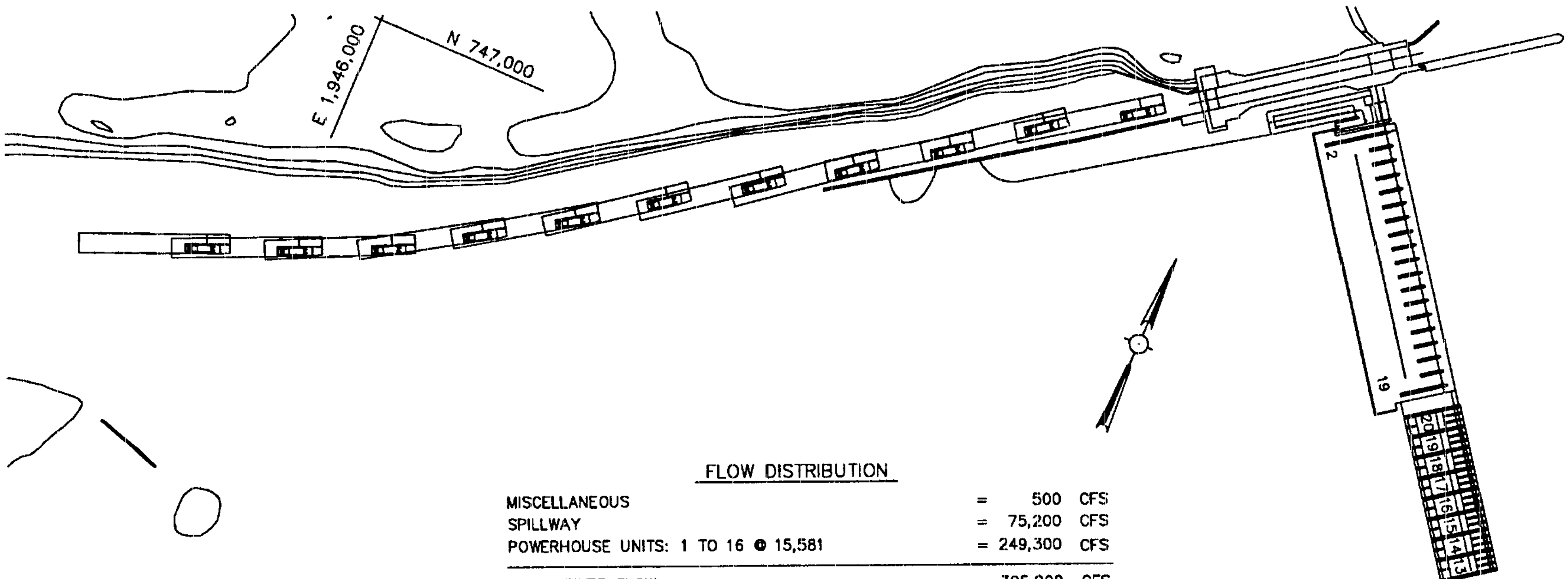
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
ENTERING LOCK
1997 SPILL PATTERN
DISCHARGE: 350,000 CFS
LOWER POOL EL: 164.4 FT

JD-214



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 75,200	CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,581	= 249,300	CFS
TOTAL RIVER FLOW	= 325,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	4.5	4.5	3

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NO DEFLECTORS IN

SCALES IN FEET

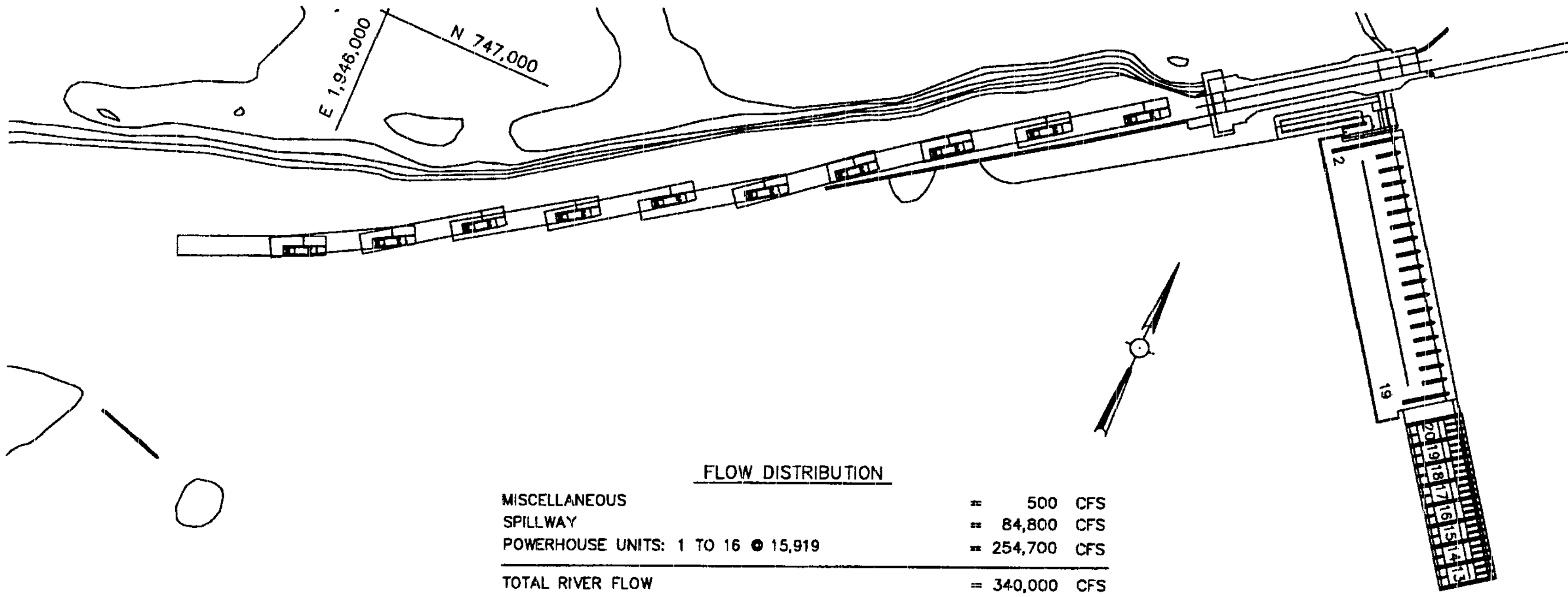
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
EXITING LOCK
1997 SPILL PATTERN
DISCHARGE: 325,000 CFS
LOWER POOL EL: 163.7 FT

JD-225



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 84,800	CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,919	= 254,700	CFS
TOTAL RIVER FLOW	= 340,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	2	2	2	2	3	2	2	3	2	3	2	3	2	3	2	3	3	4.5	4.5	3

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NO DEFLECTORS IN

SCALES IN FEET

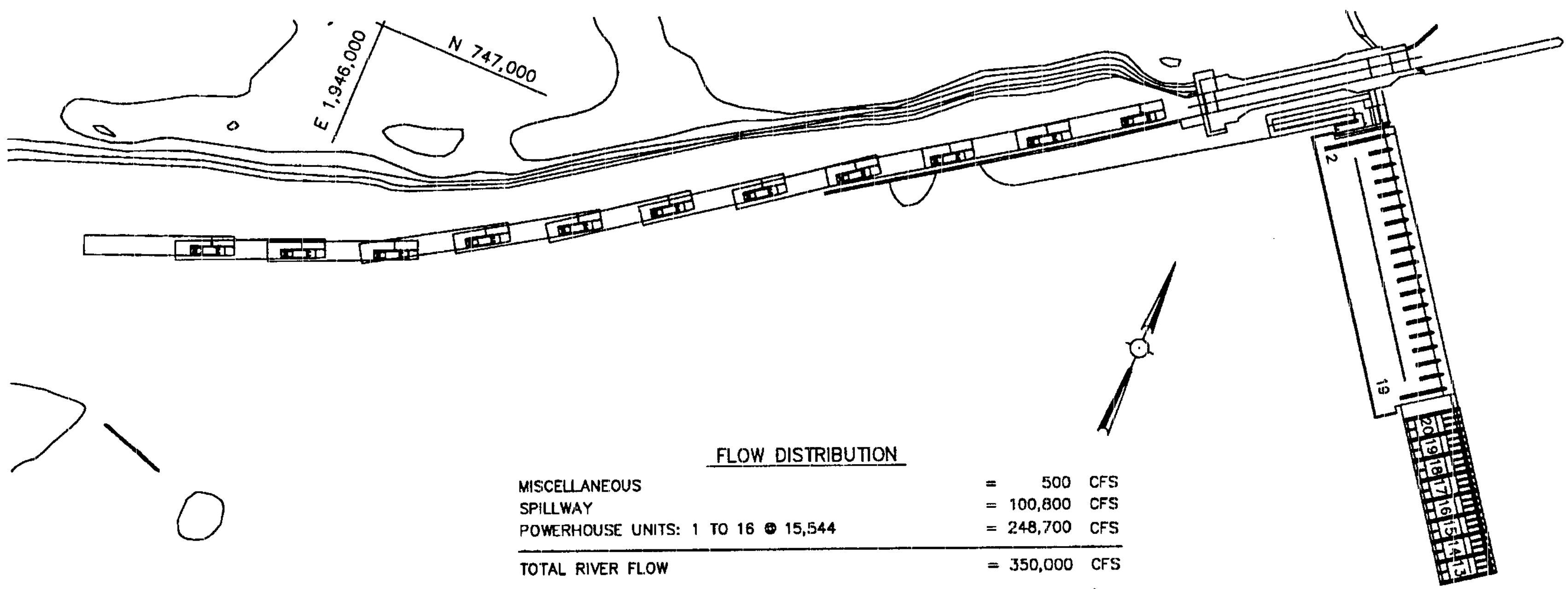
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
EXITING LOCK
1997 SPILL PATTERN
DISCHARGE: 340,000 CFS
LOWER POOL EL: 164.1 FT

JD-207



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 100,800	CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,544	= 248,700	CFS
TOTAL RIVER FLOW	= 350,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4.5	4.5	3

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NO DEFLECTORS IN

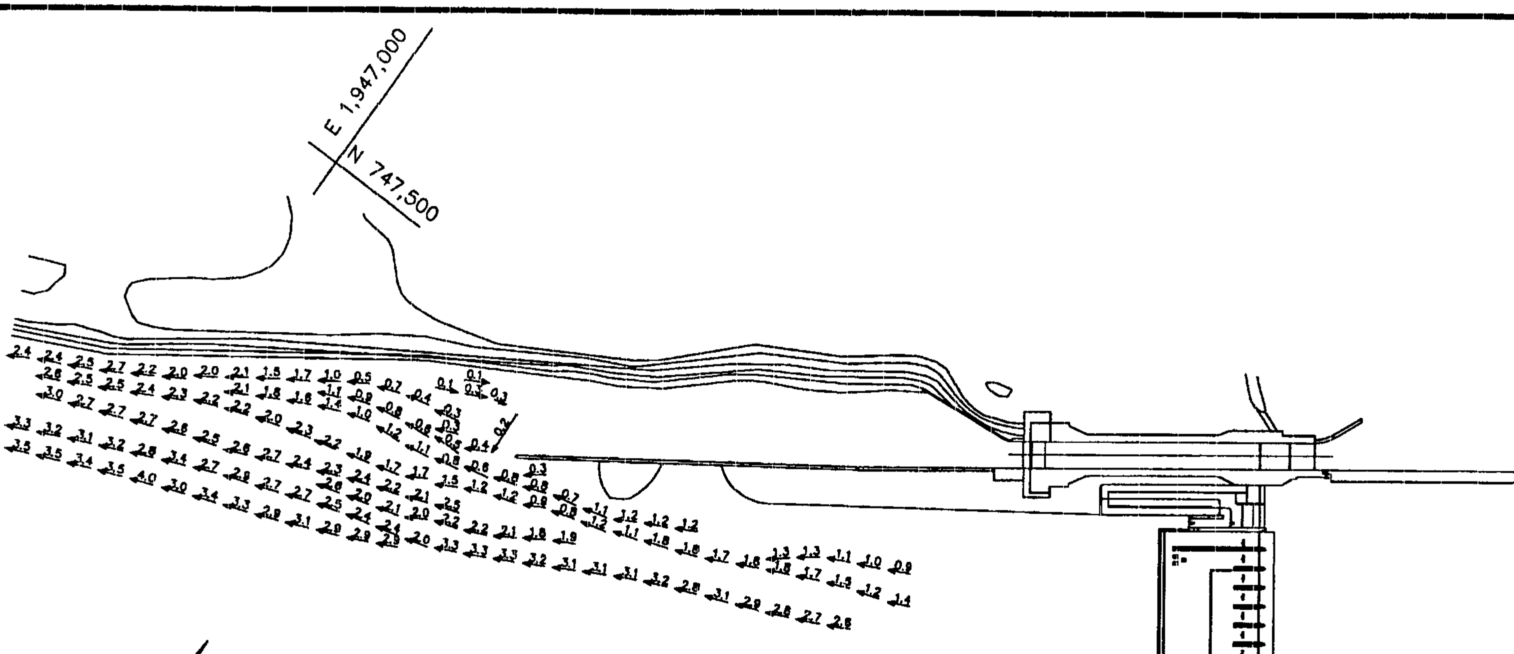
SCALES IN FEET

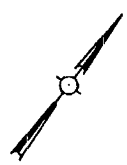
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
EXITING LOCK
1997 SPILL PATTERN
DISCHARGE: 350,000 CFS
LOWER POOL EL: 164.4 FT





FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	75,200 CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,581	=	249,300 CFS
TOTAL RIVER FLOW	=	325,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	4.5	4.5	3

LEGEND

1.0 VELOCITY IN FEET PER SECOND
(To convert feet per second to meters per second, multiply by 0.3048)

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

VELOCITIES AND CURRENT DIRECTIONS

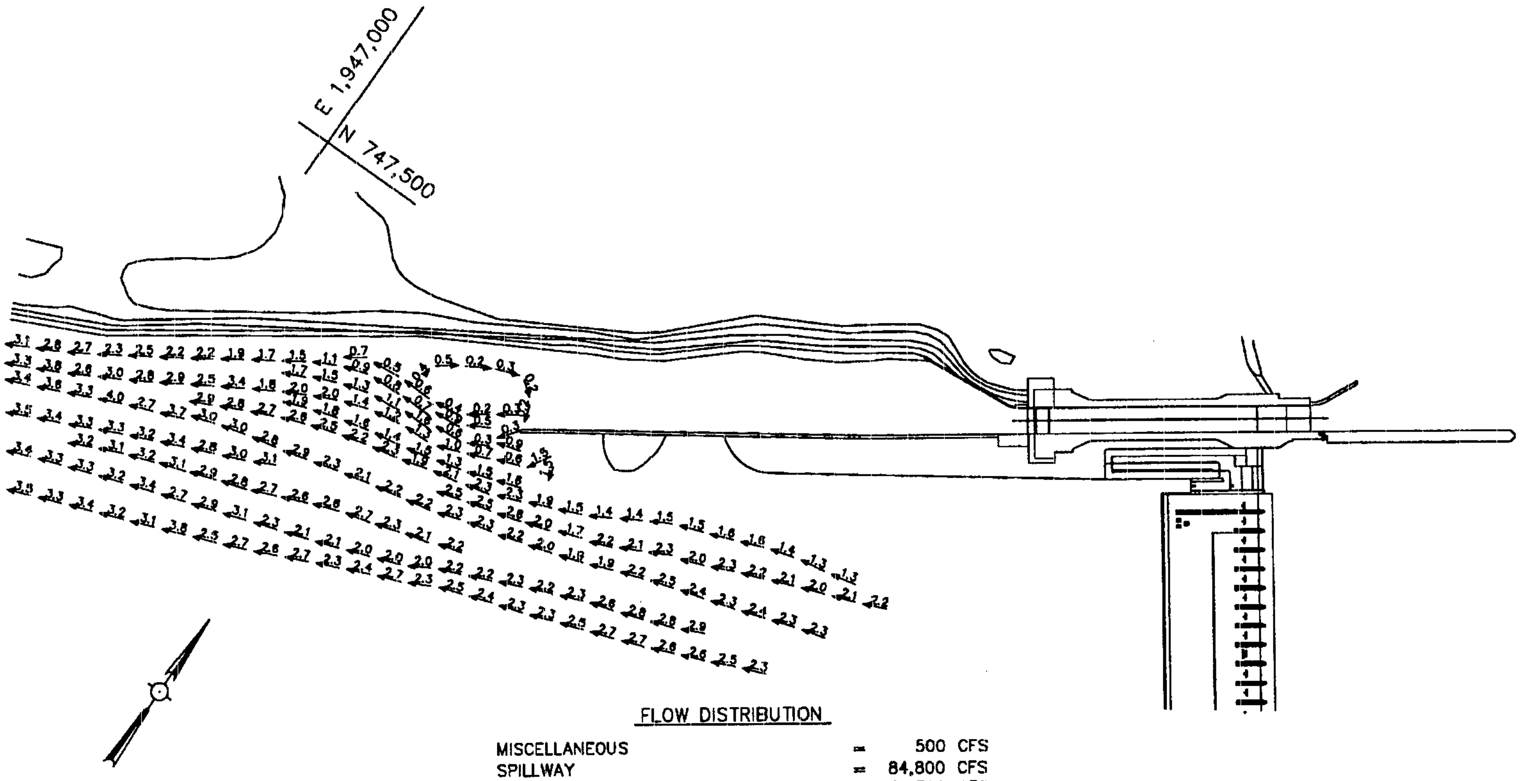
1997 SPILL PATTERN

VELOCITIES AT 14 FT

DISCHARGE: 325,000 CFS

LOWER POOL EL: 163.7 FT

JDAY-189



FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	84,800 CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,919	=	254,700 CFS
TOTAL RIVER FLOW	=	340,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	2	2	2	2	3	2	2	3	2	3	2	3	2	3	2	3	3	4.5	4.5	3

SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

LEGEND

1.0 VELOCITY IN FEET PER SECOND (To convert feet per second to meters per second, multiply by 0.3048)

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

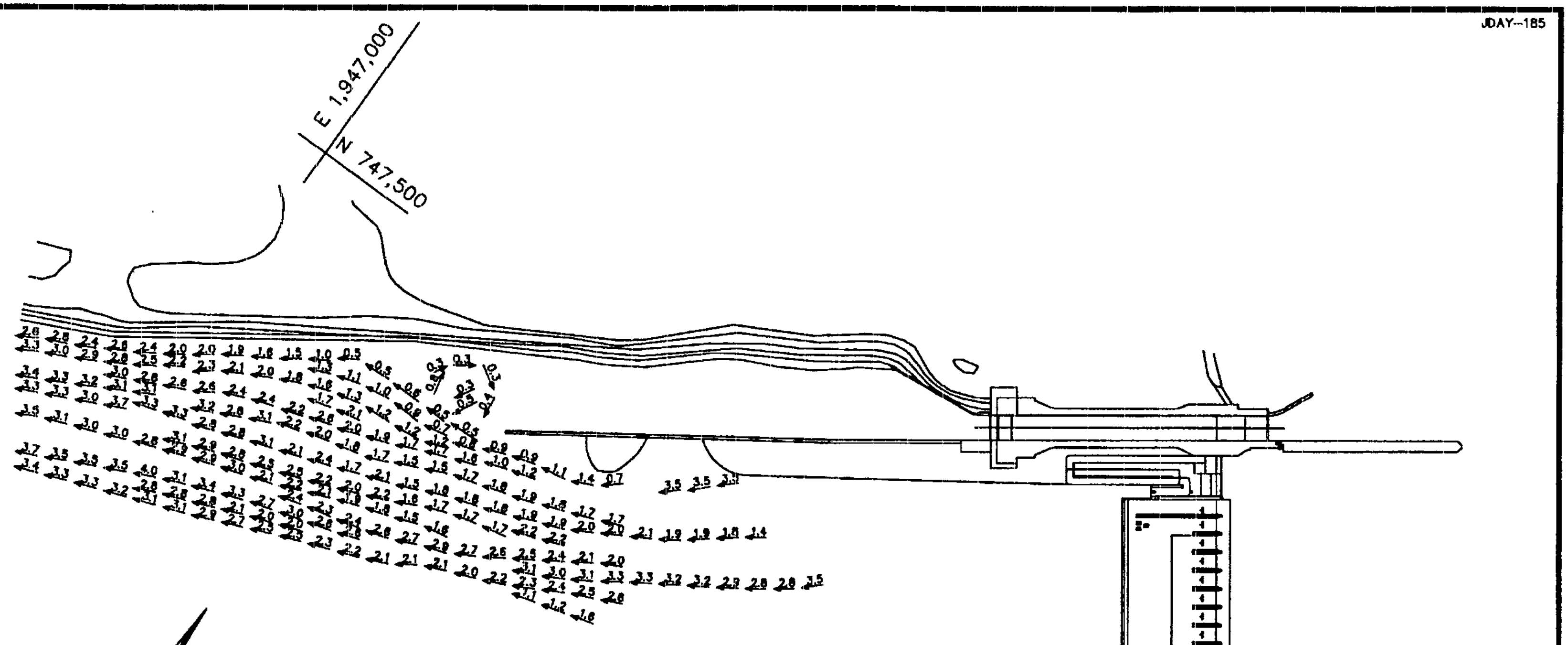
VELOCITIES AND CURRENT DIRECTIONS

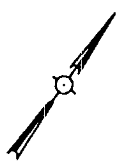
1997 SPILL PATTERN

VELOCITIES AT 14 FT

DISCHARGE: 340,000 CFS

LOWER POOL EL: 164.1 FT





FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	100,800 CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,544	=	248,700 CFS
TOTAL RIVER FLOW	=	350,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4.5	4.5	3

LEGEND

1.0 VELOCITY IN FEET PER SECOND (To cunvert feet per second to meters per second, multiply by 0.3048)

• INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

SCALES IN FEET

PROTOTYPE 0 400 800

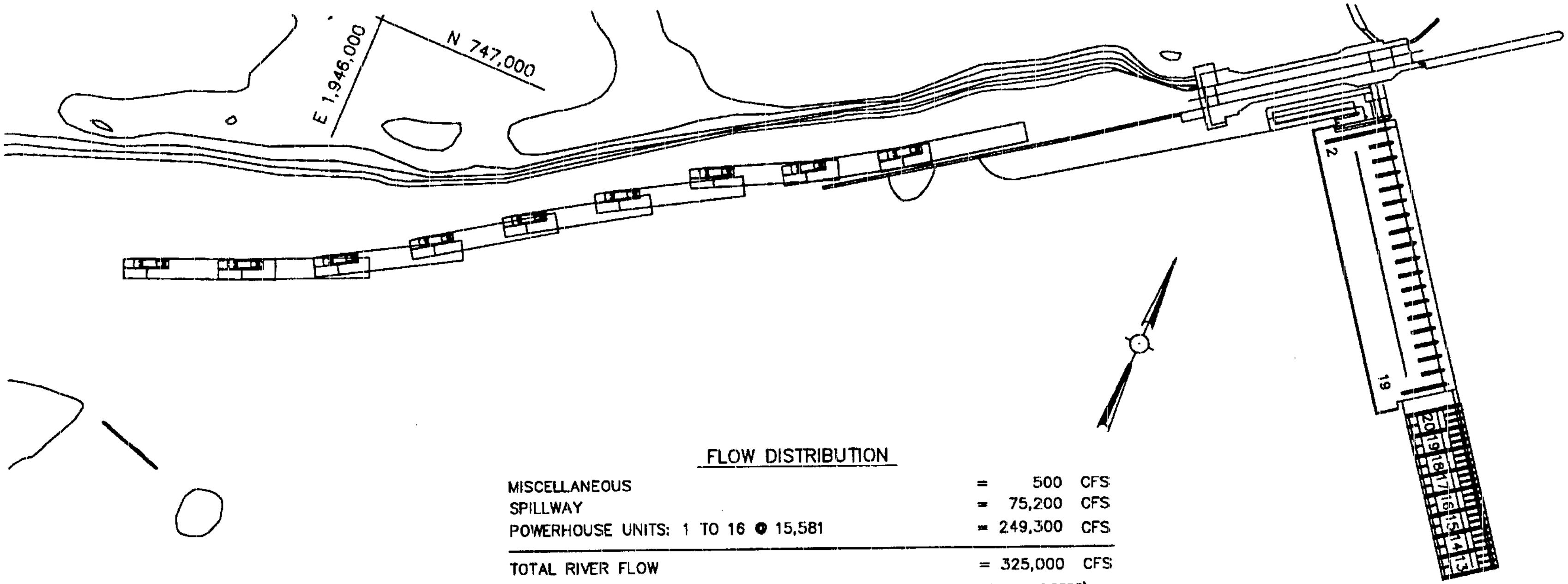
MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

VELOCITIES AND
CURRENT DIRECTIONS

1997 SPILL PATTERN
VELOCITIES AT 14 FT
DISCHARGE: 350,000 CFS
LOWER POOL EL: 164.4 FT

JD-212



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 75,200	CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,581	= 249,300	CFS
TOTAL RIVER FLOW	= 325,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	4.5	4.5	3

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

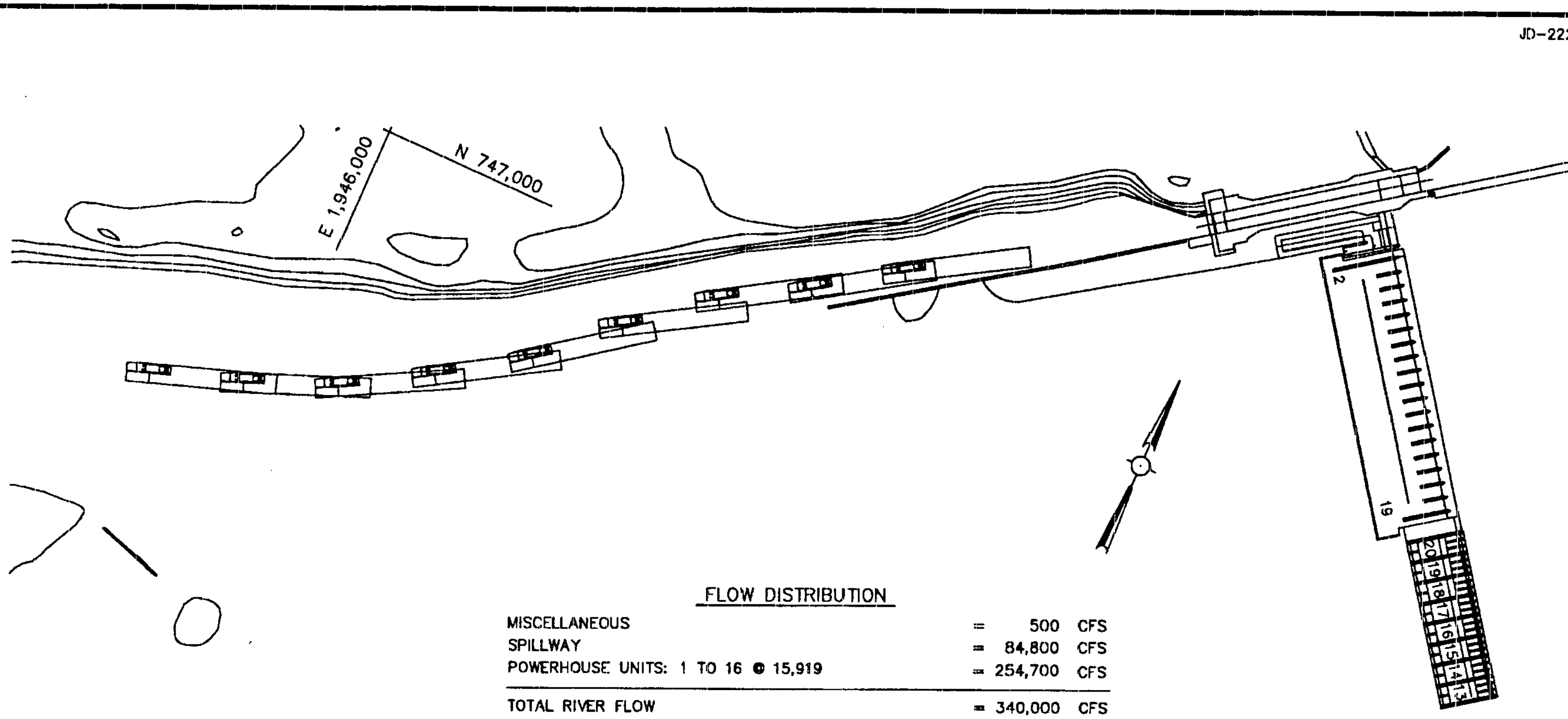
SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
ENTERING LOCK
1997 SPILL PATTERN
DISCHARGE: 325,000 CFS
LOWER POOL EL: 163.7 FT



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 84,800	CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,919	= 254,700	CFS
TOTAL RIVER FLOW	= 340,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	2	2	2	2	3	2	2	3	2	3	2	3	2	3	2	3	3	4.5	4.5	3

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

SCALES IN FEET

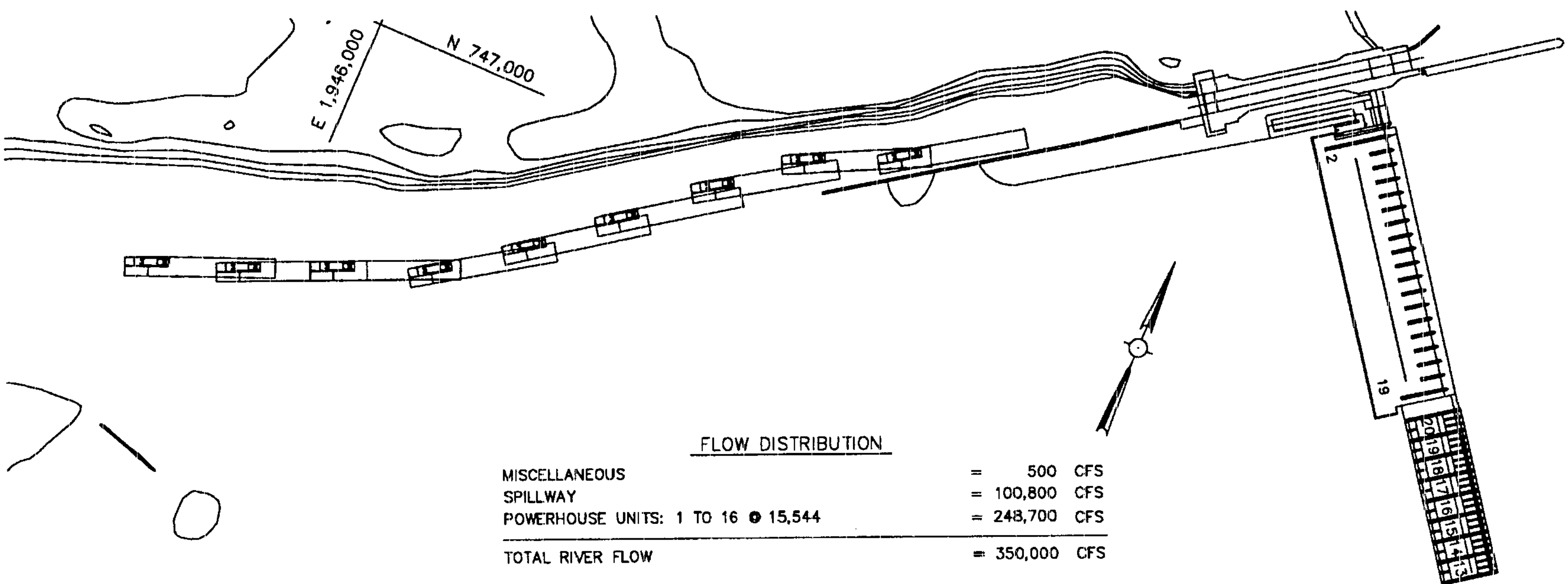
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
ENTERING LOCK
1997 SPILL PATTERN
DISCHARGE: 340,000 CFS
LOWER POOL EL: 164.1 FT

JD-209



FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	100,800 CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,544	=	248,700 CFS
TOTAL RIVER FLOW	=	350,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4.5	4.5	3

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

SCALES IN FEET

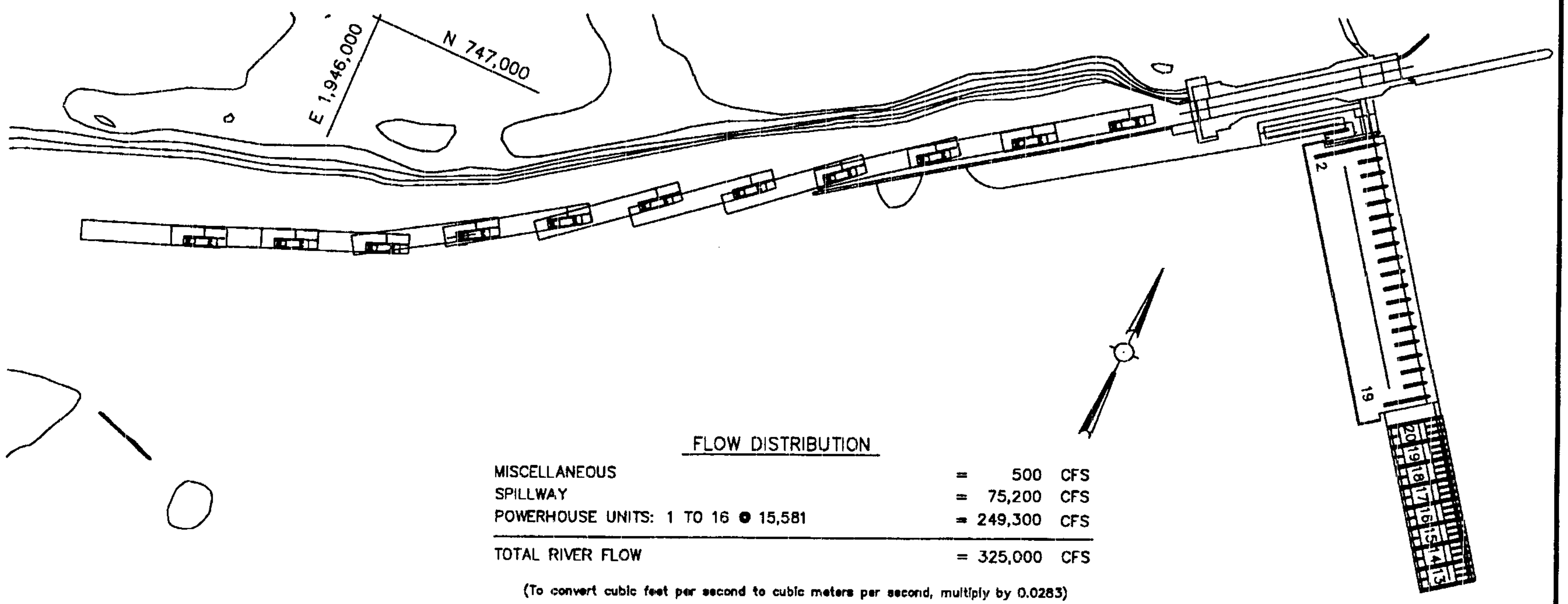
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
ENTERING LOCK
1997 SPILL PATTERN
DISCHARGE: 350,000 CFS
LOWER POOL EL: 164.4 FT

JD-213



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 75,200	CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,581	= 249,300	CFS
TOTAL RIVER FLOW	= 325,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	4.5	4.5	3

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

SCALES IN FEET

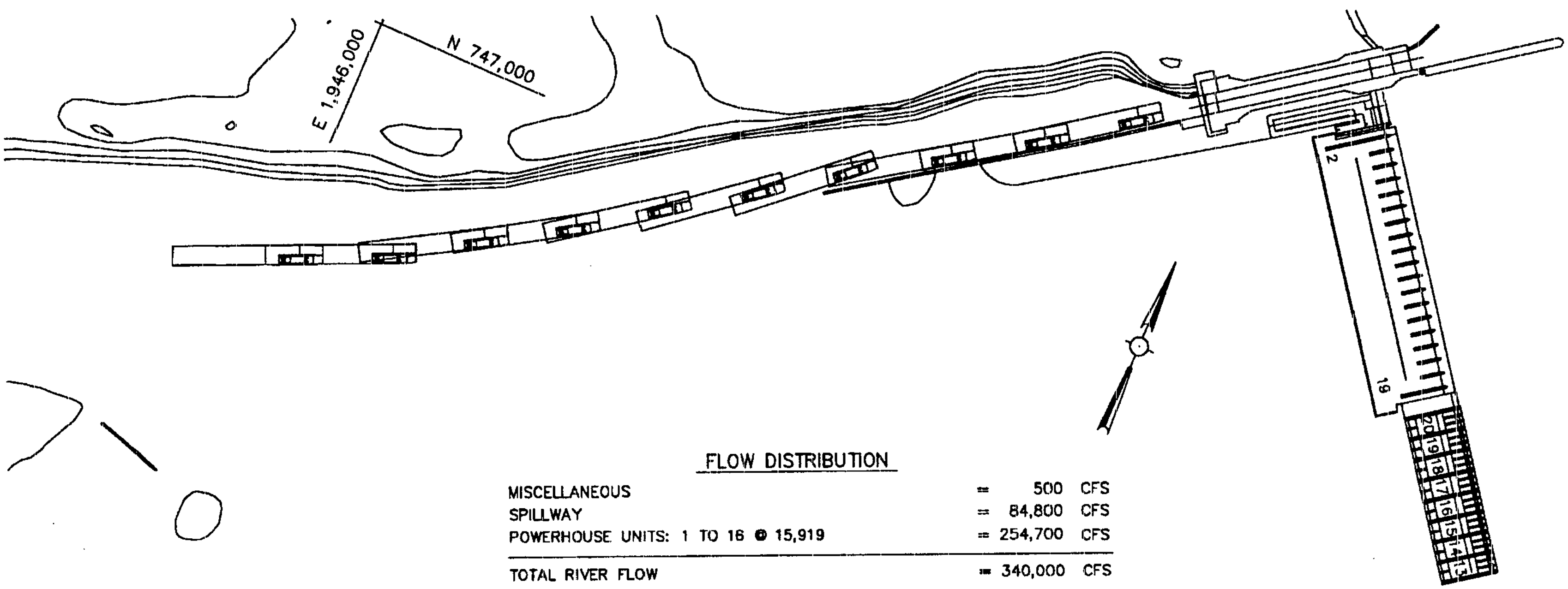
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
EXITING LOCK
1997 SPILL PATTERN
DISCHARGE: 325,000 CFS
LOWER POOL EL: 163.7 FT

JD-223



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 84,800	CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,919	= 254,700	CFS
TOTAL RIVER FLOW	= 340,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	2	2	2	2	3	2	2	3	2	3	2	3	2	3	2	3	3	4.5	4.5	3

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

SCALES IN FEET

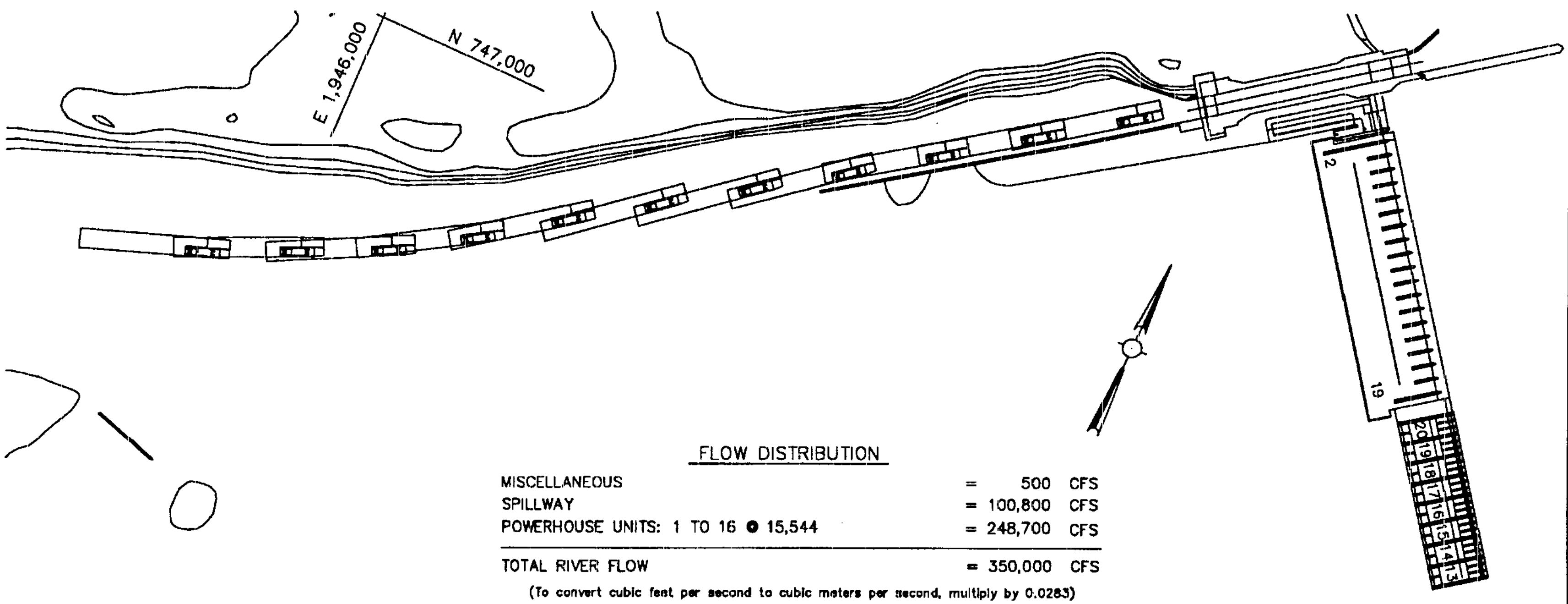
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
EXITING LOCK
1997 SPILL PATTERN
DISCHARGE: 340,000 CFS
LOWER POOL EL: 164.1 FT

JD-208



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 100,800	CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,544	= 248,700	CFS
TOTAL RIVER FLOW	= 350,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4.5	4.5	3

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

SCALES IN FEET

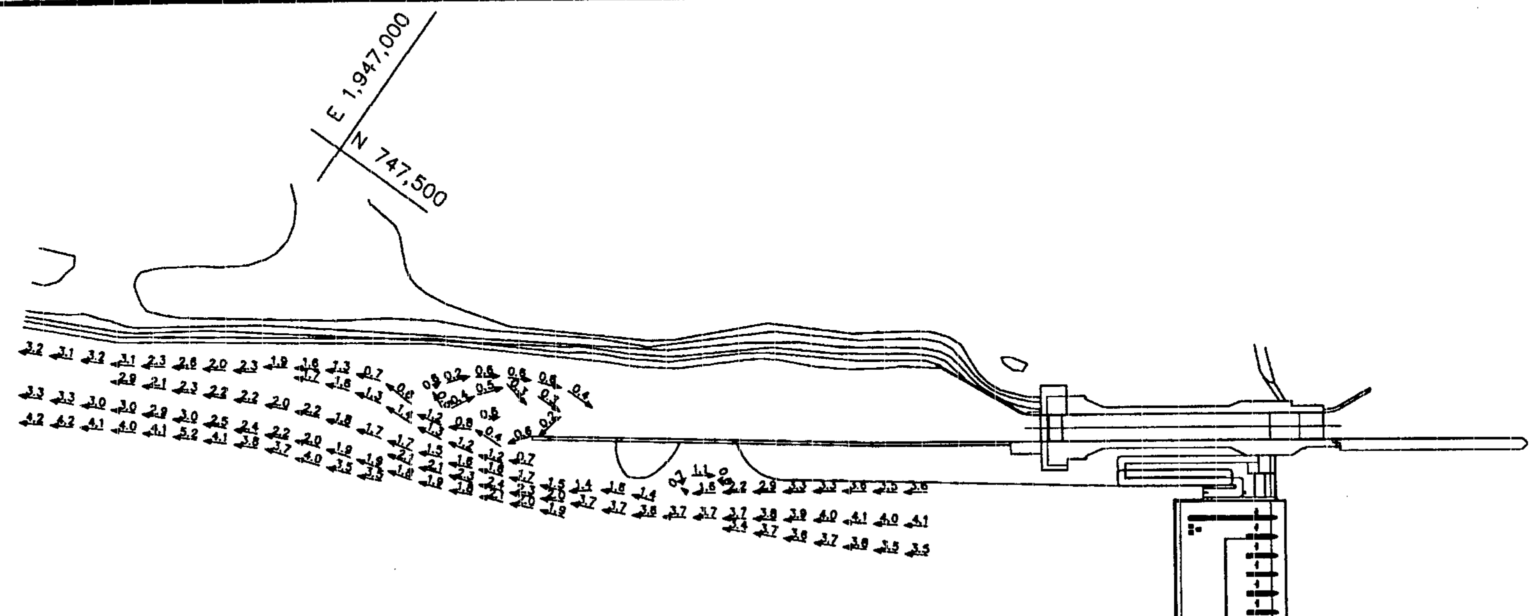
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
EXITING LOCK
1997 SPILL PATTERN
DISCHARGE: 350,000 CFS
LOWER POOL EL: 164.4 FT

JDAY--194



FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	75,200 CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,581	=	249,300 CFS
TOTAL RIVER FLOW	=	325,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	4	4	4	4	3	3	3	3	3	2	2	2	2	2	2	1	●	●	●

SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

LEGEND

1.0 VELOCITY IN FEET PER SECOND (To convert feet per second to meters per second, multiply by 0.3048)

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NO DEFLECTORS IN

VELOCITIES AND CURRENT DIRECTIONS

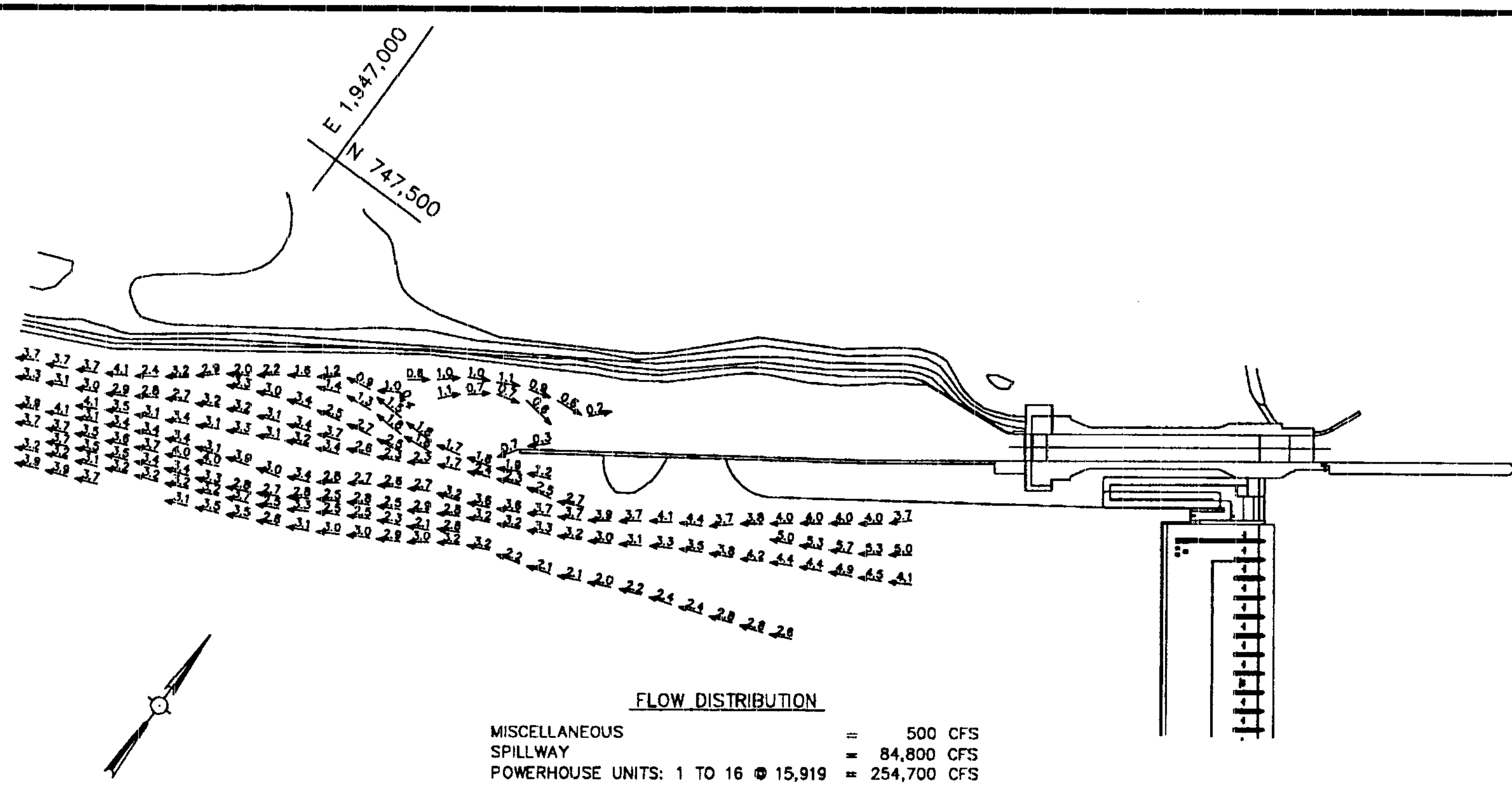
1998 SPILL PATTERN

VELOCITIES AT 14 FT

DISCHARGE: 325,000 CFS

LOWER POOL EL: 163.7 FT

JDAY-196



FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	84,800 CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,919	=	254,700 CFS
TOTAL RIVER FLOW	=	340,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	5	5	4	4	4	3	3	3	3	3	2	2	2	2	2	2	1	●	●

SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

LEGEND

1.0 VELOCITY IN FEET PER SECOND (To convert feet per second to meters per second, multiply by 0.3048)

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NO DEFLECTORS IN

VELOCITIES AND CURRENT DIRECTIONS

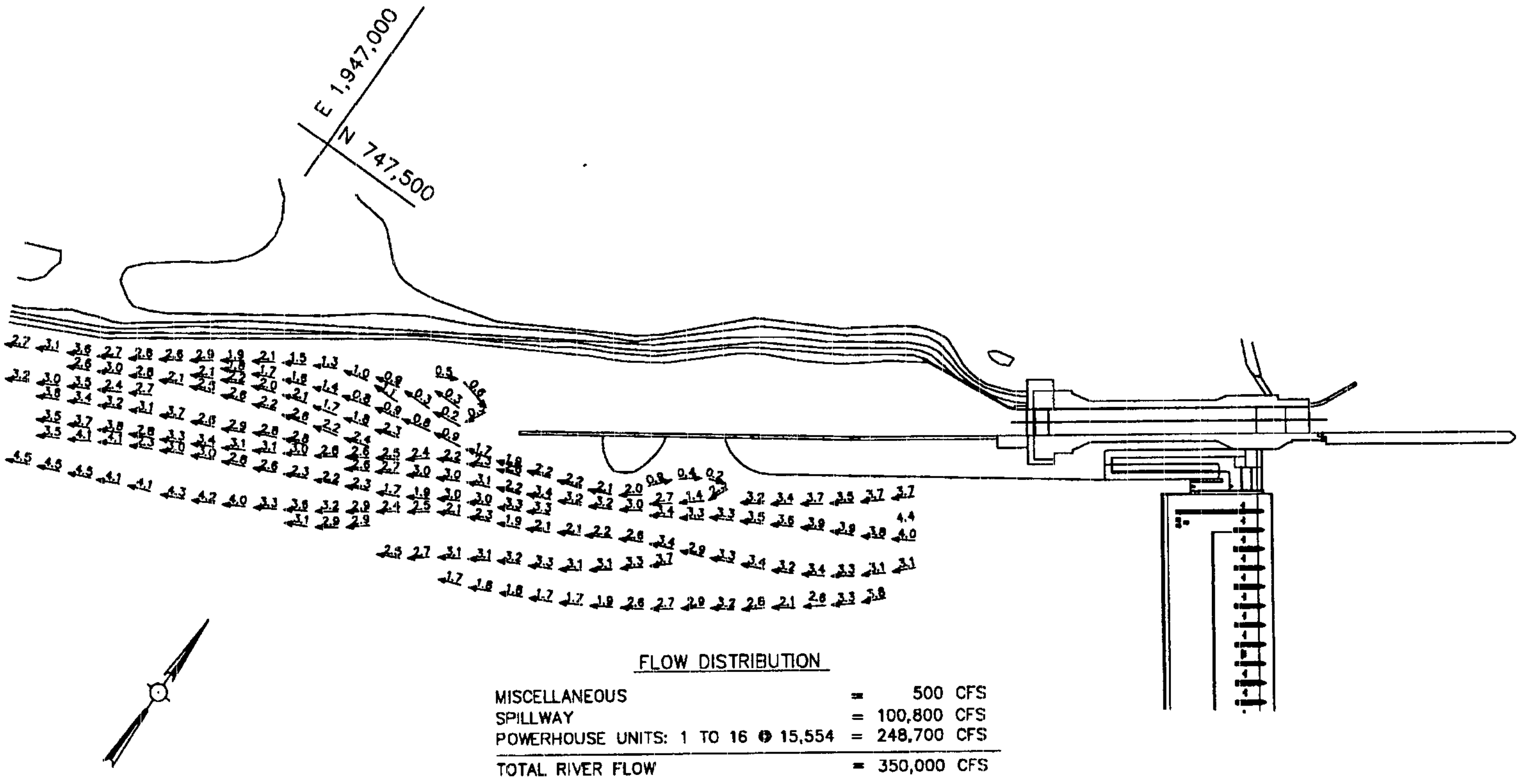
1998 SPILL PATTERN

VELOCITIES AT 14 FT

DISCHARGE: 340,000 CFS

LOWER POOL EL: 164.1 FT

JDAY-192



FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	100,800 CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,554	=	248,700 CFS
TOTAL RIVER FLOW	=	350,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	5	5	5	5	4	4	4	4	3	3	3	3	3	3	3	2	1	●	●

LEGEND

1.0 VELOCITY IN FEET PER SECOND (To convert feet per second to meters per second, multiply by 0.3048)

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NO DEFLECTORS IN

SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

VELOCITIES AND CURRENT DIRECTIONS

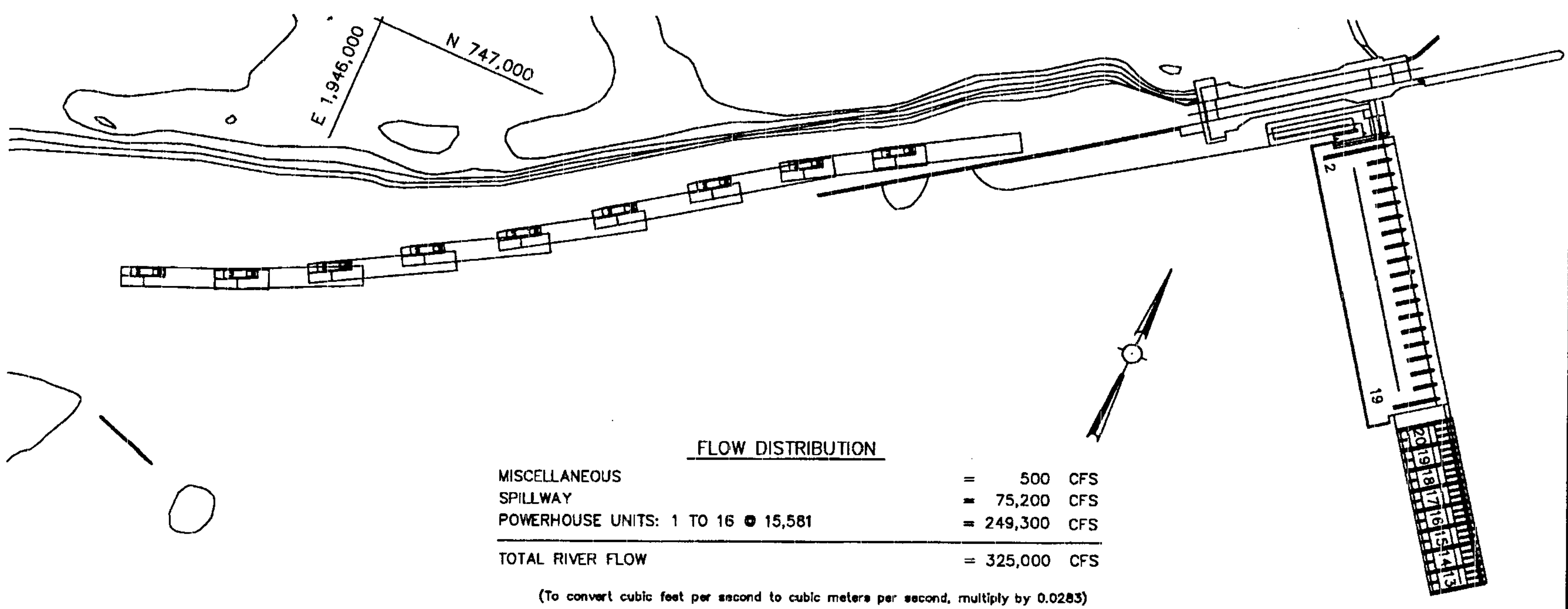
1998 SPILL PATTERN

VELOCITIES AT 14 FT

DISCHARGE: 350,000 CFS

LOWER POOL EL: 164.4 FT

JD-218



FLOW DISTRIBUTION

MISCELLANEOUS	= 500 CFS
SPILLWAY	= 75,200 CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,581	= 249,300 CFS
TOTAL RIVER FLOW	= 325,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	4	4	4	4	3	3	3	3	3	2	2	2	2	2	2	1	●	●	●

LEGEND

- 84 FT X 650 FT
- ● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NO DEFLECTORS IN

SCALES IN FEET

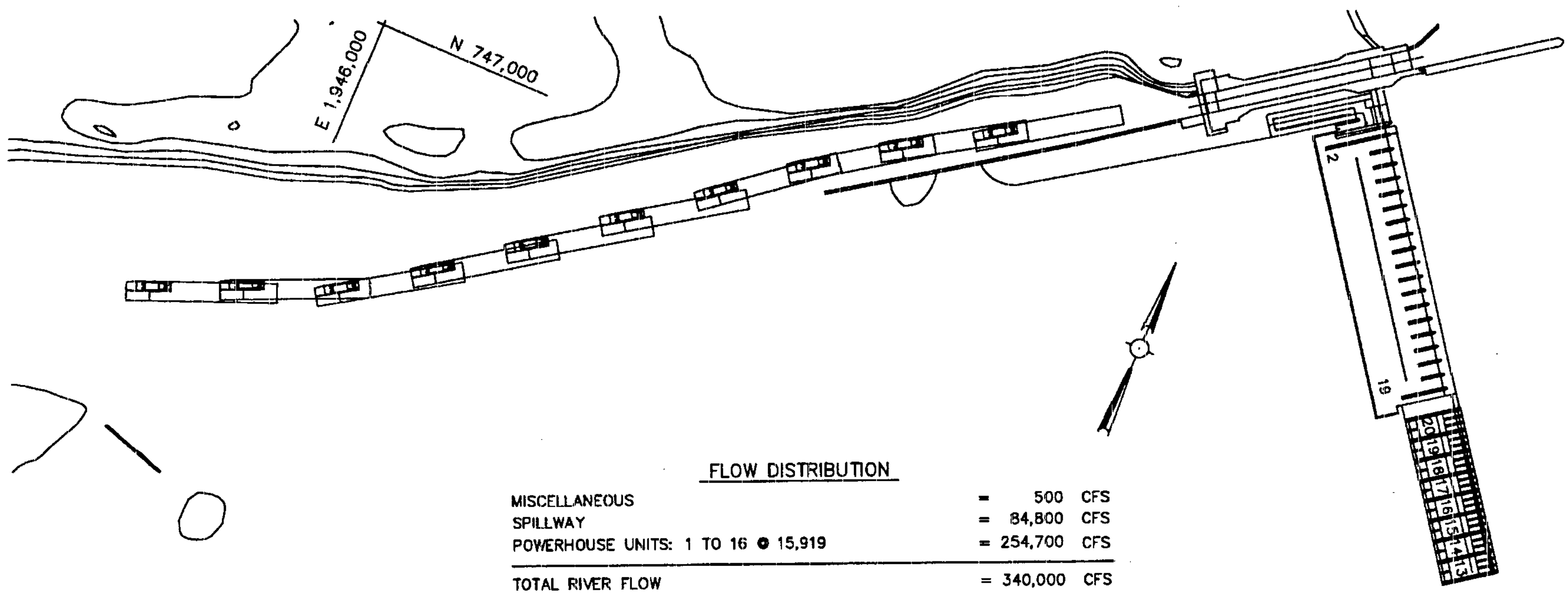
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
ENTERING LOCK
1998 SPILL PATTERN
DISCHARGE: 325,000 CFS
LOWER POOL EL: 163.7 FT

JD-227



FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	84,800 CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,919	=	254,700 CFS
TOTAL RIVER FLOW	=	340,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	5	5	4	4	4	3	3	3	3	3	2	2	2	2	2	2	1	●	●

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NO DEFLECTORS IN

SCALES IN FEET

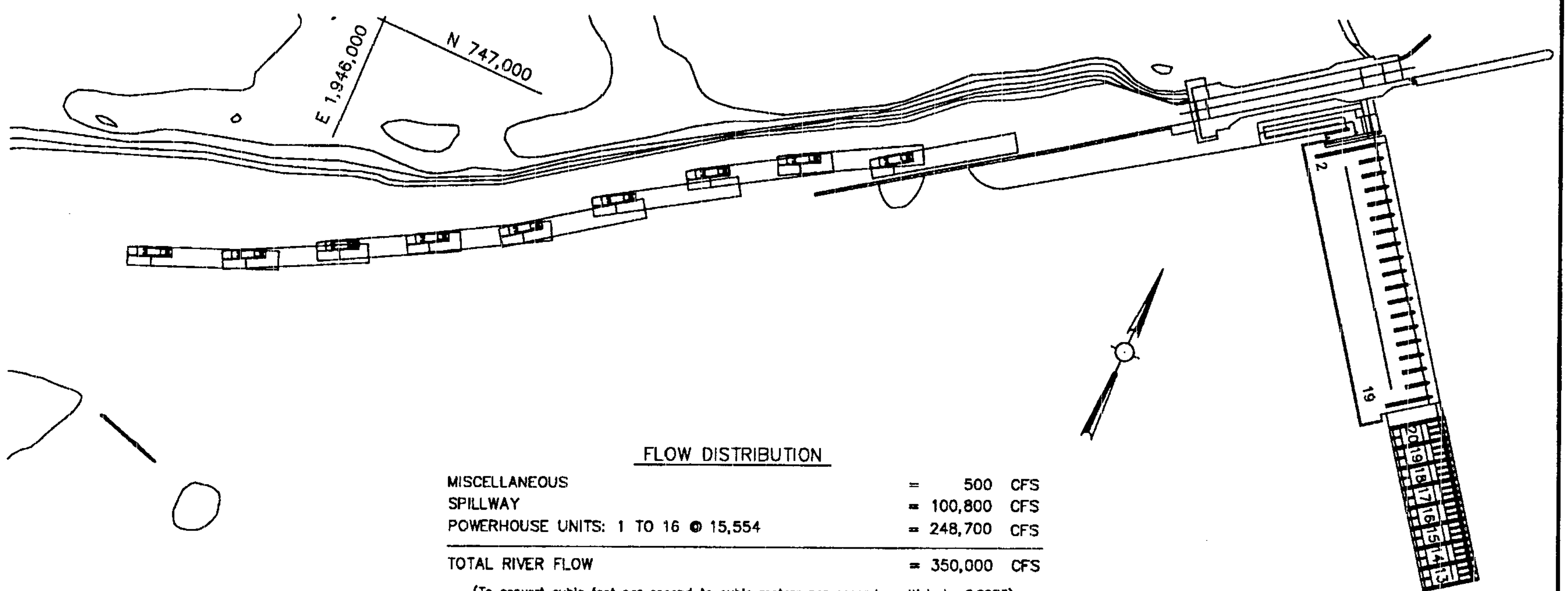
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
ENTERING LOCK
1998 SPILL PATTERN
DISCHARGE: 340,000 CFS
LOWER POOL EL: 164.1 FT

JD-205



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 100,800	CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,554	= 248,700	CFS
TOTAL RIVER FLOW	= 350,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	5	5	5	5	4	4	4	4	3	3	3	3	3	3	3	2	1	●	●

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NO DEFLECTORS IN

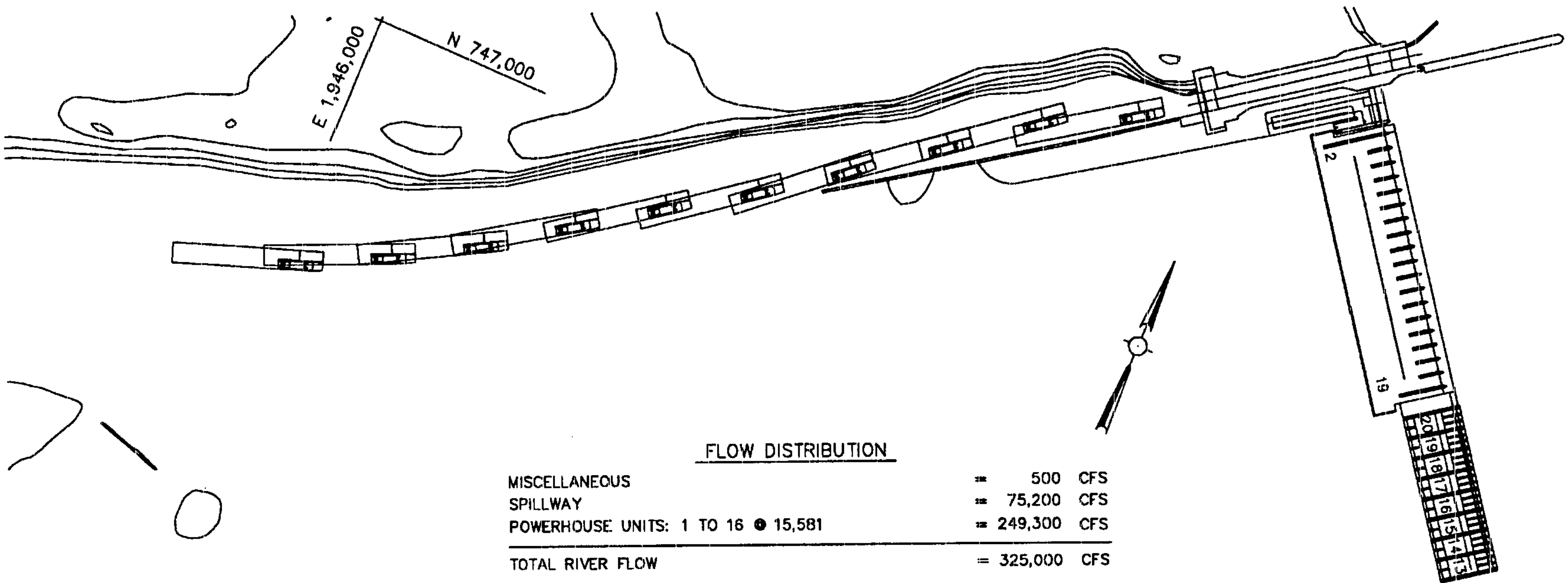
SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
ENTERING LOCK
1998 SPILL PATTERN
DISCHARGE: 350,000 CFS
LOWER POOL EL: 164.4 FT



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 75,200	CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,581	= 249,300	CFS
TOTAL RIVER FLOW	= 325,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	4	4	4	4	3	3	3	3	3	2	2	2	2	2	2	1	●	●	●

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NO DEFLECTORS IN

SCALES IN FEET

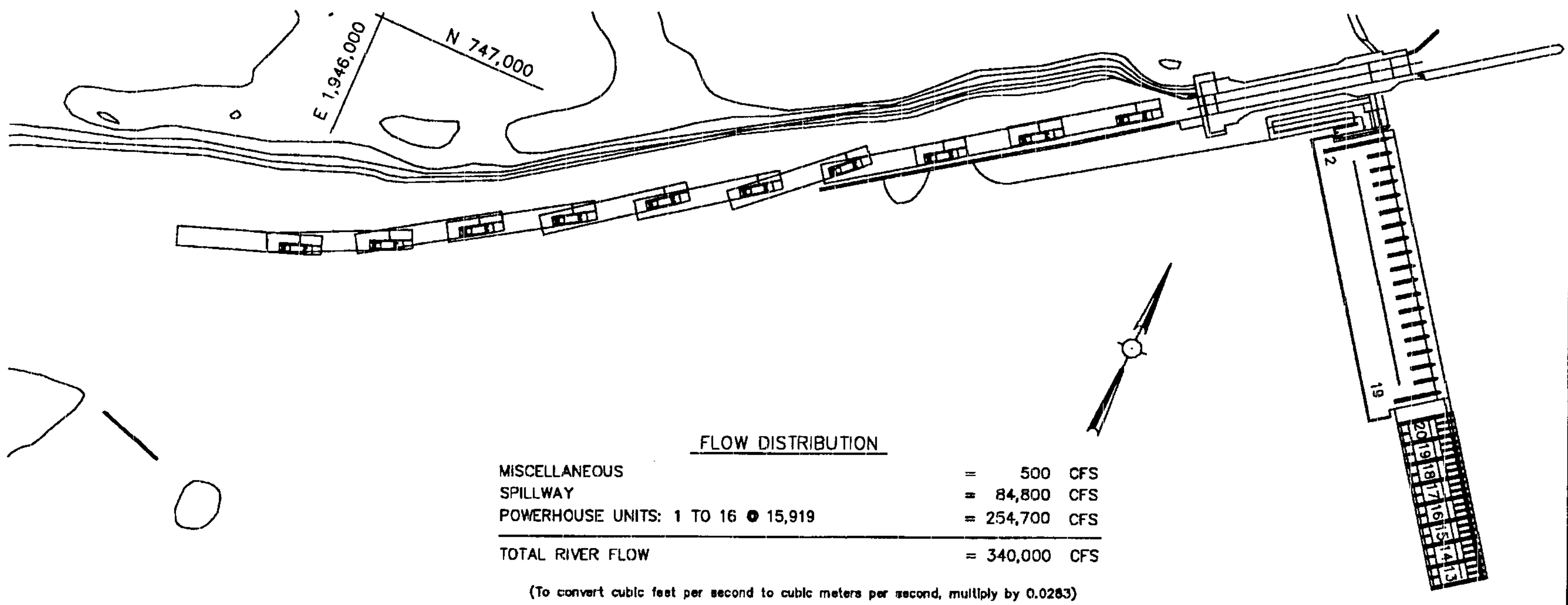
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
EXITING LOCK
1998 SPILL PATTERN
DISCHARGE: 325,000 CFS
LOWER POOL EL: 163.7 FT

JD-226



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 84,800	CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,919	= 254,700	CFS
TOTAL RIVER FLOW	= 340,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	5	5	4	4	4	3	3	3	3	3	2	2	2	2	2	2	1	●	●

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NO DEFLECTORS IN

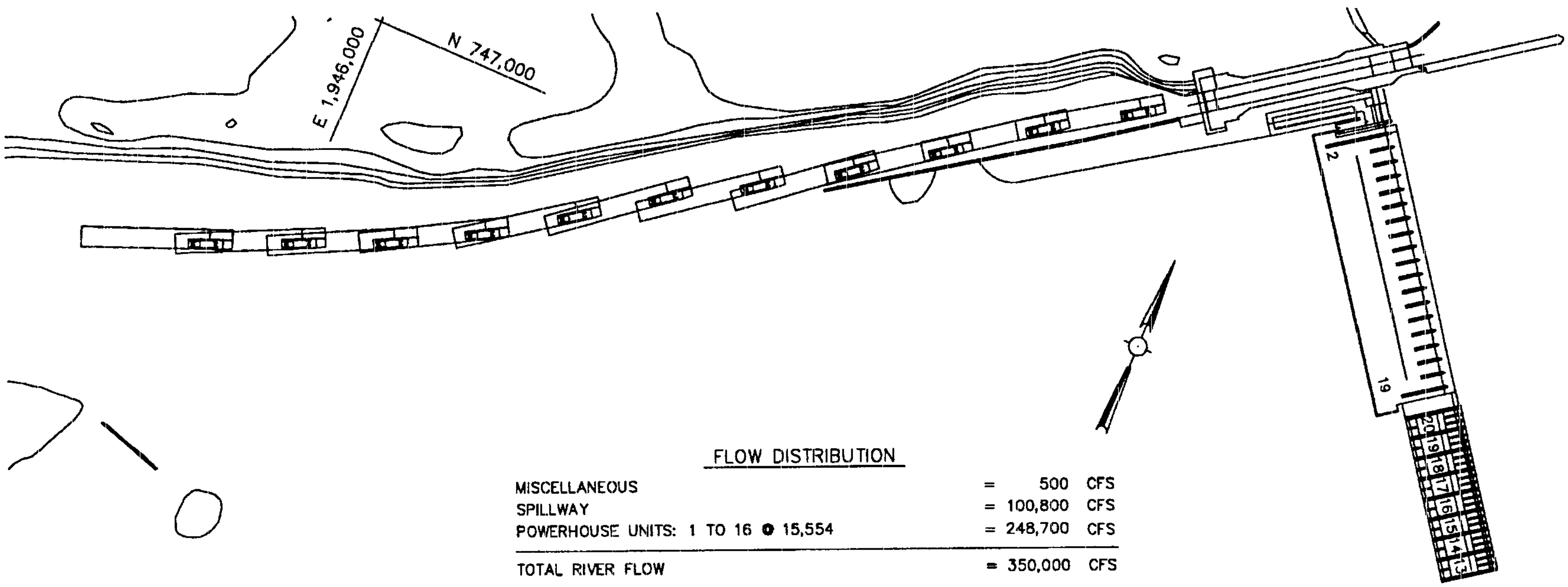
SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
EXITING LOCK
1998 SPILL PATTERN
DISCHARGE: 340,000 CFS
LOWER POOL EL: 164.1 FT



FLOW DISTRIBUTION

MISCELLANEOUS	= 500 CFS
SPILLWAY	= 100,800 CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,554	= 248,700 CFS
TOTAL RIVER FLOW	= 350,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	5	5	5	5	4	4	4	4	3	3	3	3	3	3	3	2	1	●	●

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

NO DEFLECTORS IN

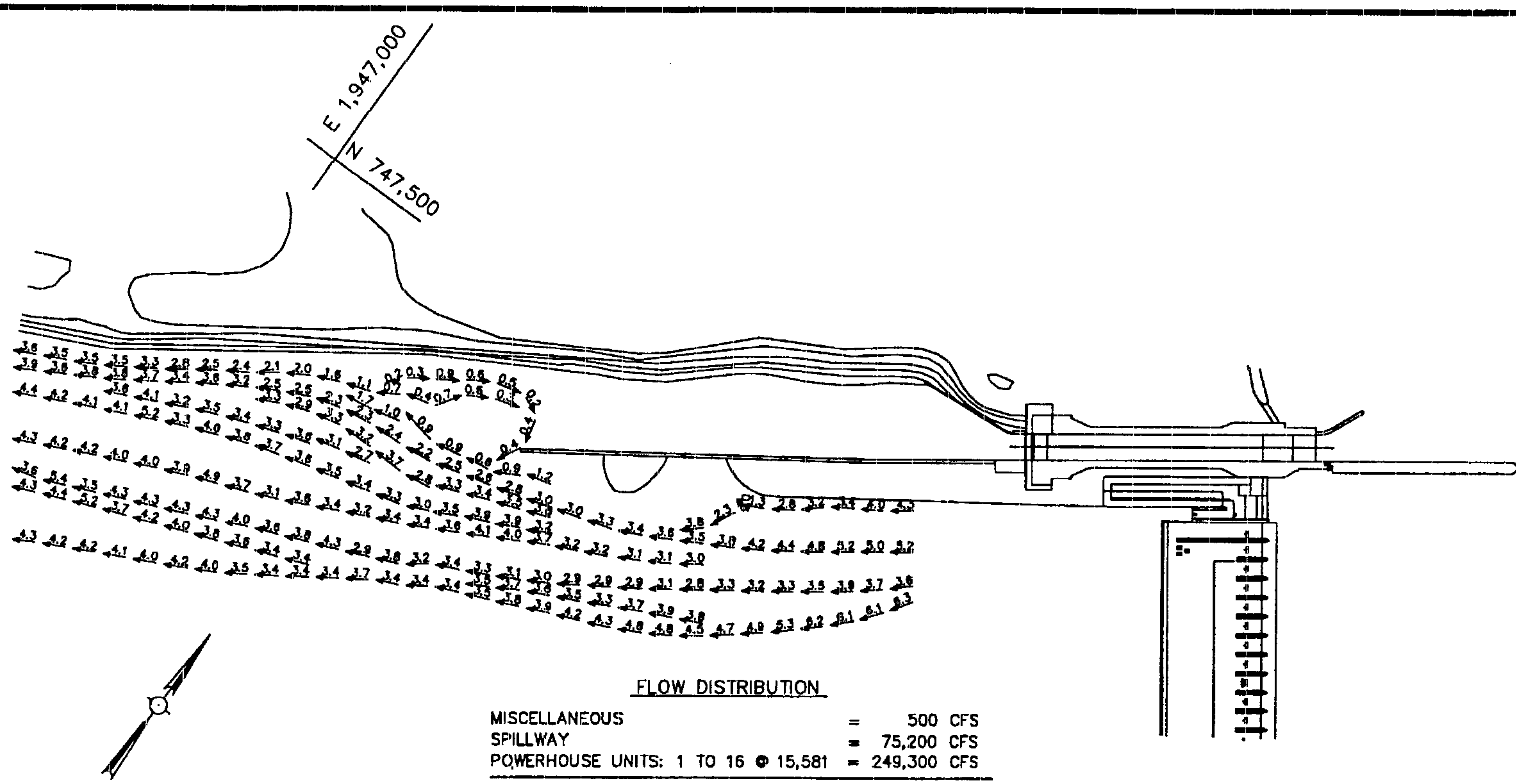
SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
EXITING LOCK
1998 SPILL PATTERN
DISCHARGE: 350,000 CFS
LOWER POOL EL: 164.4 FT



FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	75,200 CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,581	=	249,300 CFS
TOTAL RIVER FLOW	=	325,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	4	4	4	4	3	3	3	3	3	2	2	2	2	2	2	1	●	●	●

LEGEND

1.0 VELOCITY IN FEET PER SECOND (To convert feet per second to meters per second, multiply by 0.3048)

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

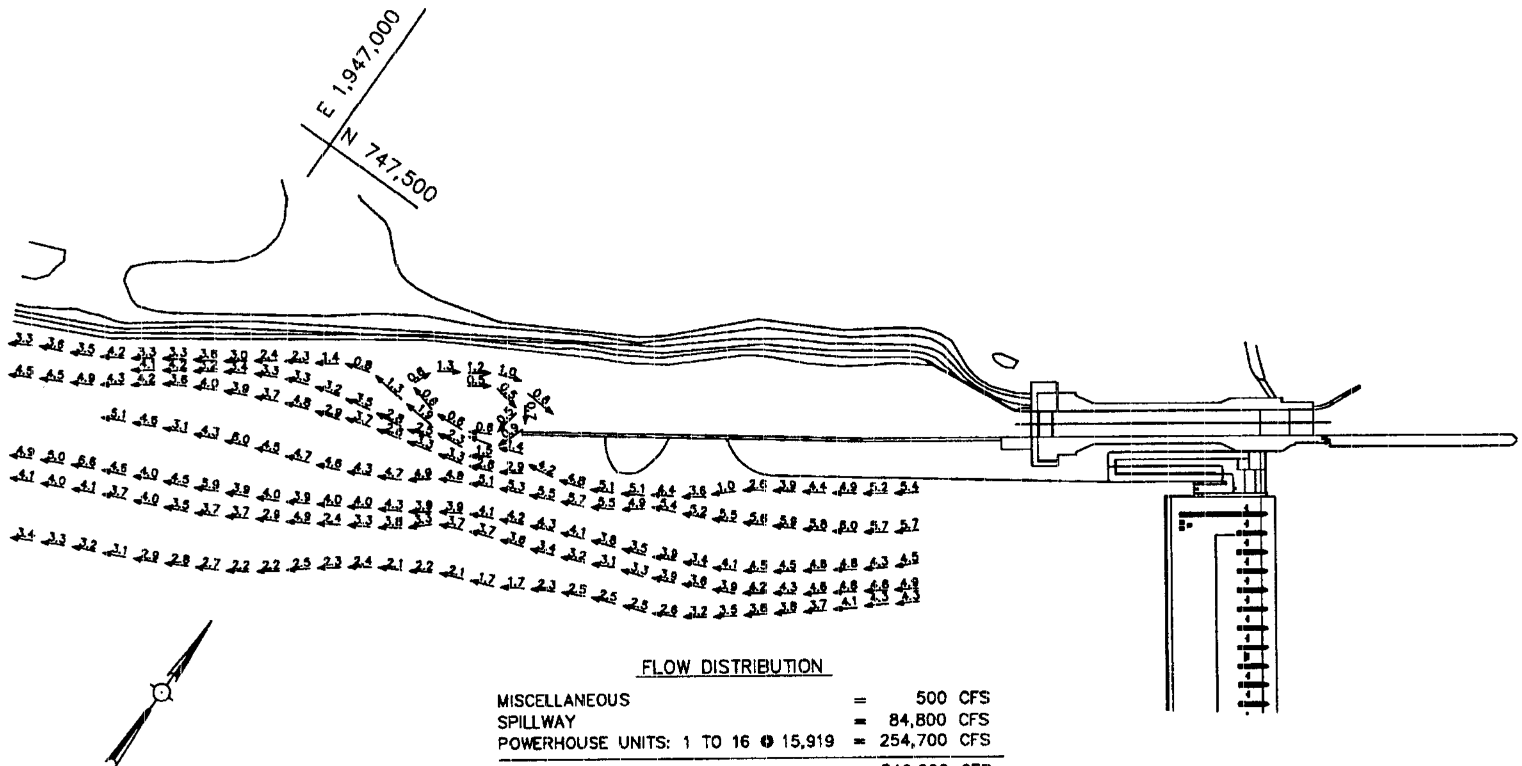
VELOCITIES AND CURRENT DIRECTIONS

1998 SPILL PATTERN

VELOCITIES AT 14 FT

DISCHARGE: 325,000 CFS

LOWER POOL EL: 163.7 FT



FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	84,800 CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,919	=	254,700 CFS
TOTAL RIVER FLOW	=	340,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	5	5	4	4	4	3	3	3	3	3	2	2	2	2	2	2	1	●	●

SCALES IN FEET

PROTOTYPE 0 — 400 — 800

MODEL 0 — 5 — 10

(To convert feet to meters, multiply by 0.3048)

LEGEND

1.0 VELOCITY IN FEET PER SECOND (To convert feet per second to meters per second, multiply by 0.3048)

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

VELOCITIES AND CURRENT DIRECTIONS

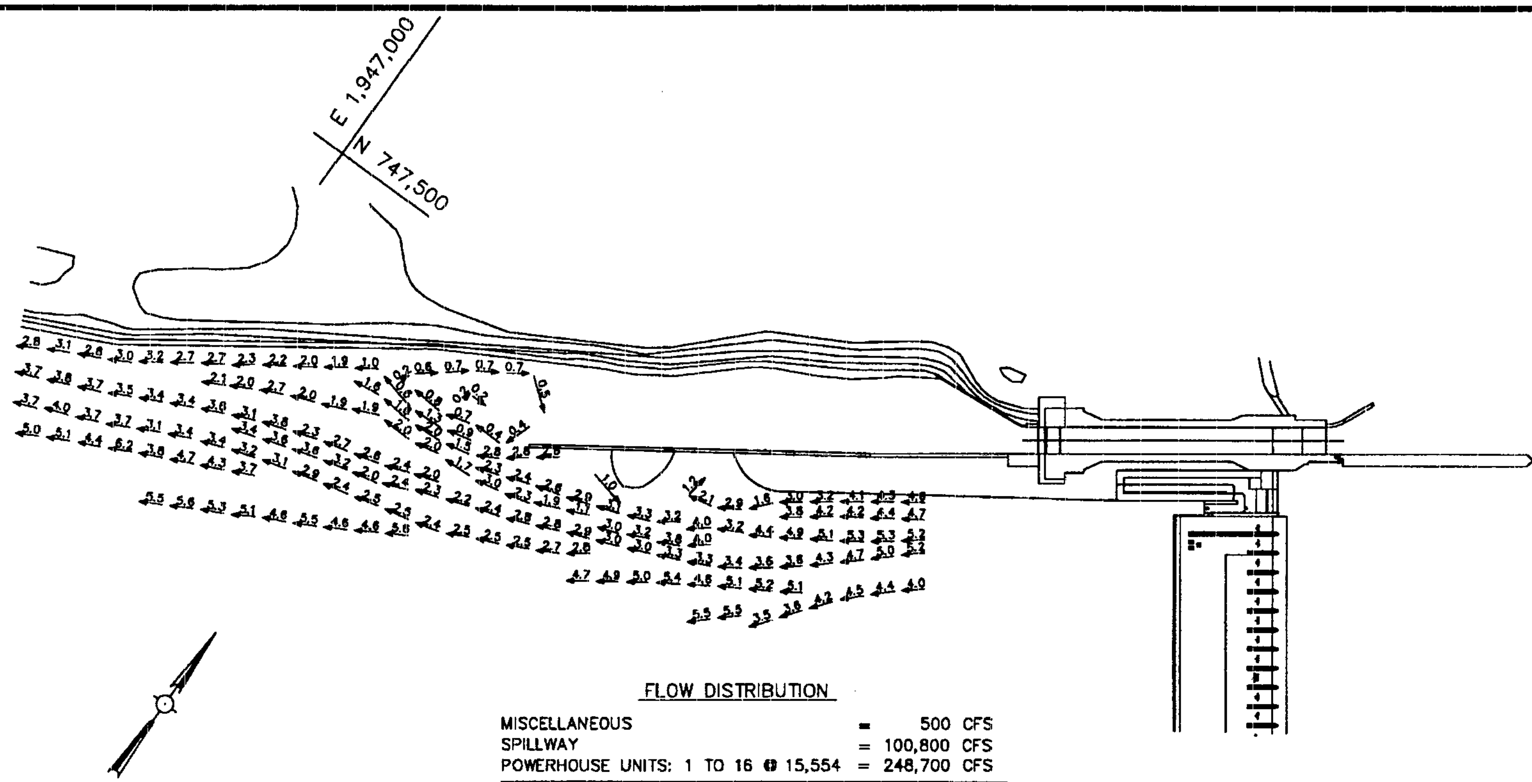
1998 SPILL PATTERN

VELOCITIES AT 14 FT

DISCHARGE: 340,000 CFS

LOWER POOL EL: 164.1 FT

JDAY-191



FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	100,800 CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,554	=	248,700 CFS
TOTAL RIVER FLOW	=	350,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	5	5	5	5	4	4	4	4	3	3	3	3	3	3	3	2	1	●	●

SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

LEGEND

1.0 VELOCITY IN FEET PER SECOND (To convert feet per second to meters per second, multiply by 0.3048)

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

VELOCITIES AND CURRENT DIRECTIONS

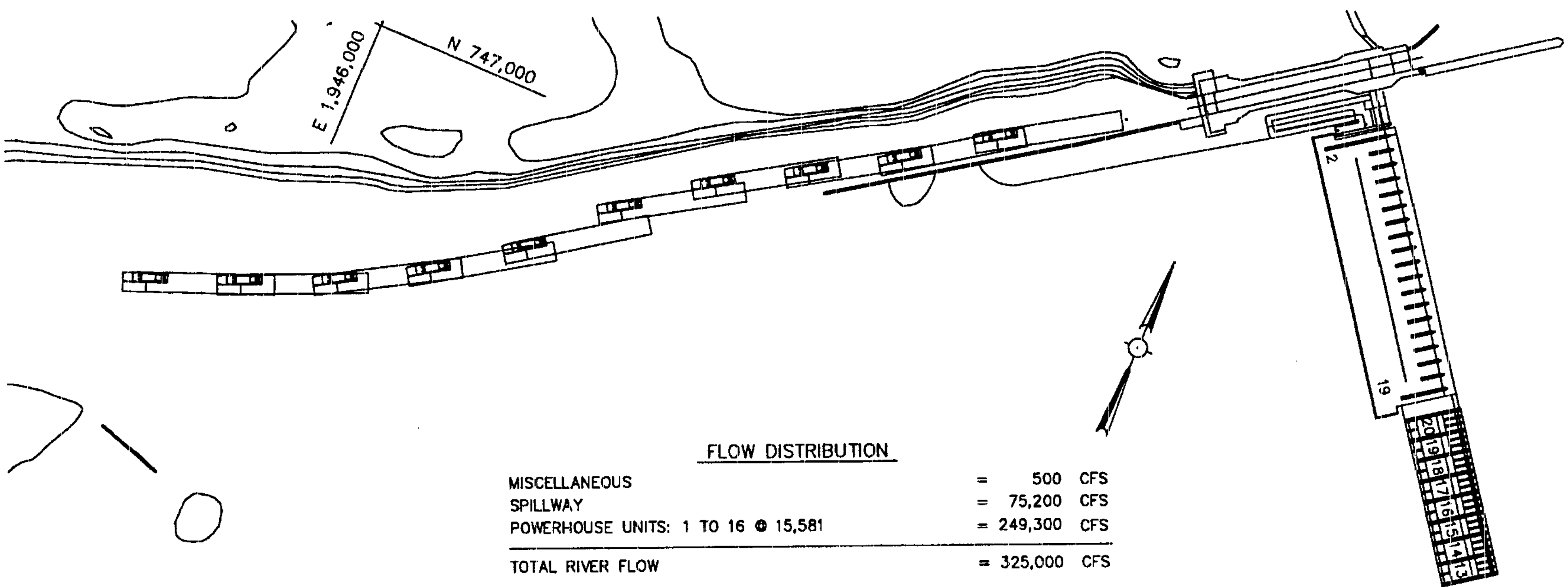
1998 SPILL PATTERN

VELOCITIES AT 14 FT

DISCHARGE: 350,000 CFS

LOWER POOL EL: 164.4 FT

JD-217



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 75,200	CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,581	= 249,300	CFS
TOTAL RIVER FLOW	= 325,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	4	4	4	4	3	3	3	3	3	2	2	2	2	2	2	1	●	●	●

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

SCALES IN FEET

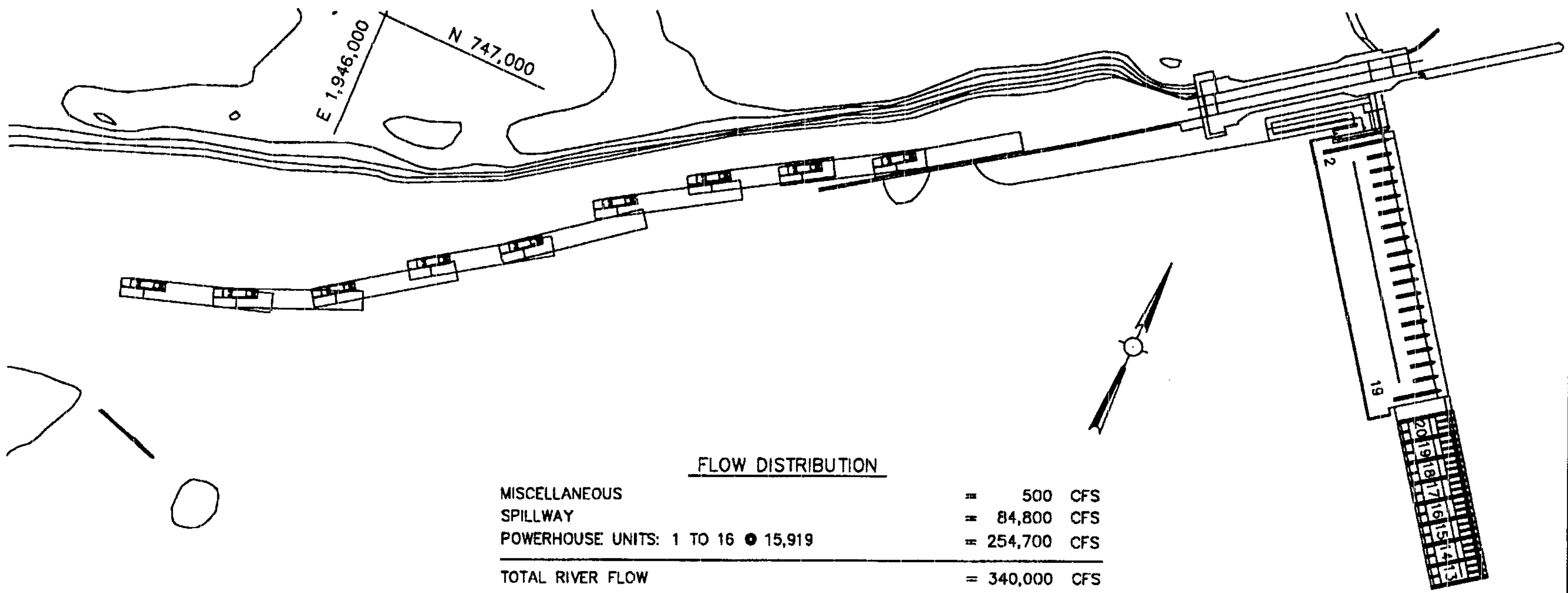
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
ENTERING LOCK
1998 SPILL PATTERN
DISCHARGE: 325,000 CFS
LOWER POOL EL: 163.7 FT

JD-228



FLOW DISTRIBUTION

MISCELLANEOUS	= 500 CFS
SPILLWAY	= 84,800 CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,919	= 254,700 CFS
TOTAL RIVER FLOW	= 340,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	5	5	4	4	4	3	3	3	3	3	2	2	2	2	2	2	1	●	●

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

SCALES IN FEET

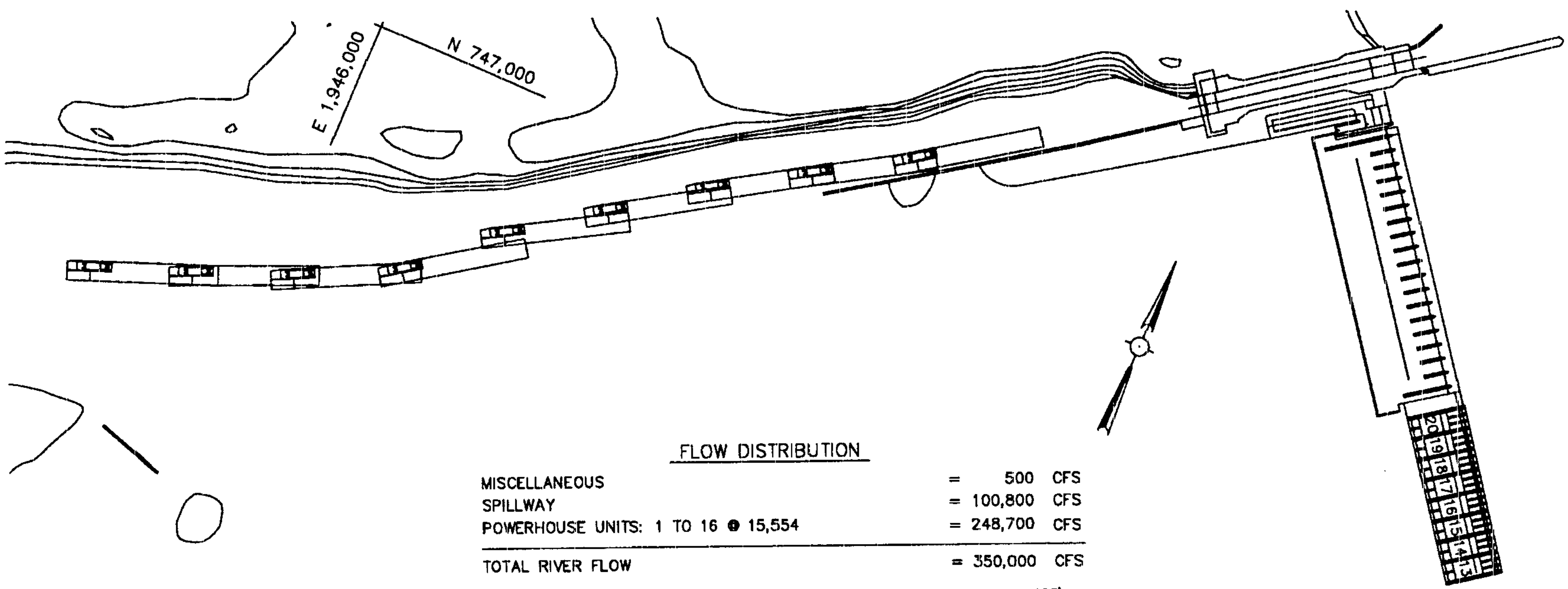
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
ENTERING LOCK
1998 SPILL PATTERN
DISCHARGE: 340,000 CFS
LOWER POOL EL: 164.1 FT

JD-202



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 100,800	CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,554	= 248,700	CFS
TOTAL RIVER FLOW	= 350,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	5	5	5	5	4	4	4	4	3	3	3	3	3	3	3	2	1	●	●

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

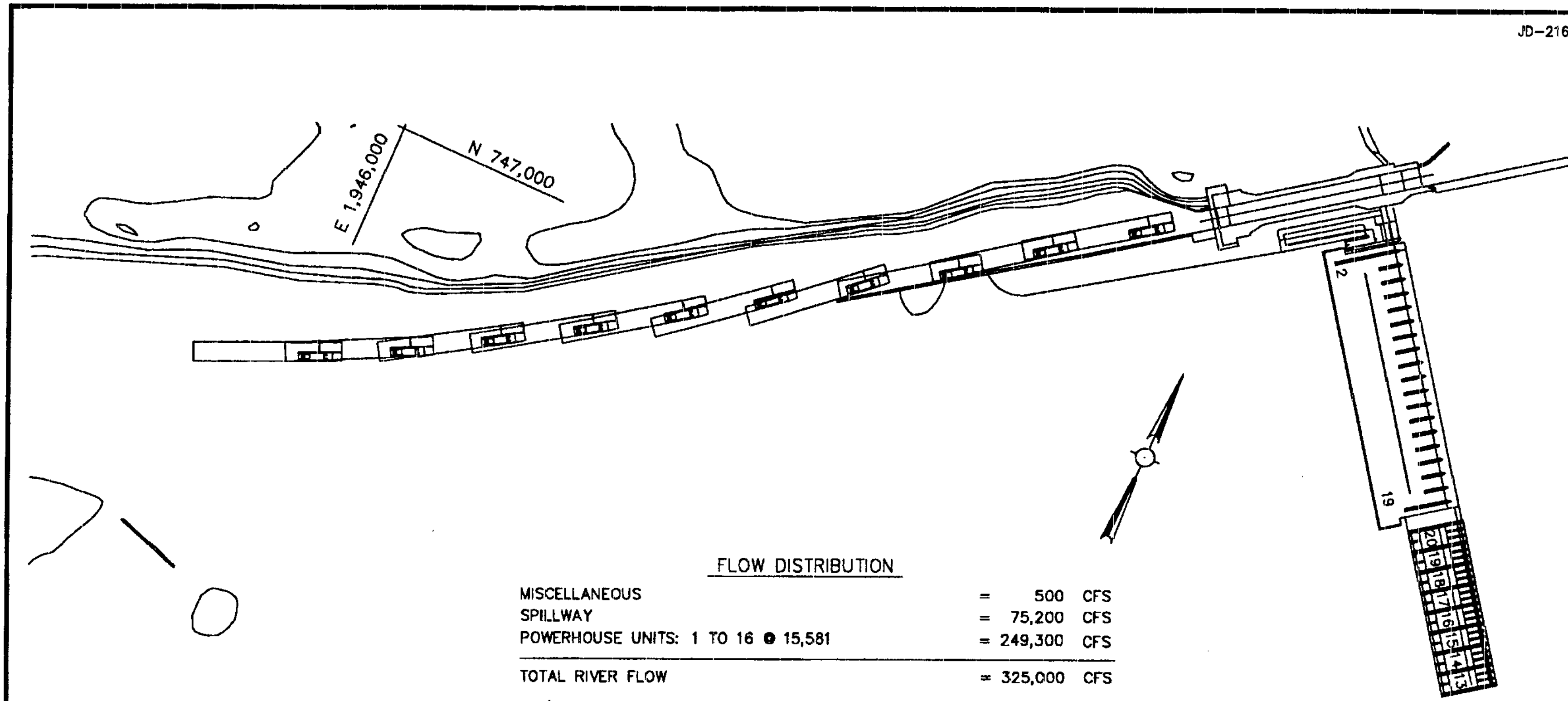
SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
ENTERING LOCK
1998 SPILL PATTERN
DISCHARGE: 350,000 CFS
LOWER POOL EL: 164.4 FT



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 75,200	CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,581	= 249,300	CFS
TOTAL RIVER FLOW	= 325,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	4	4	4	4	3	3	3	3	3	2	2	2	2	2	2	1	●	●	●

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

SCALES IN FEET

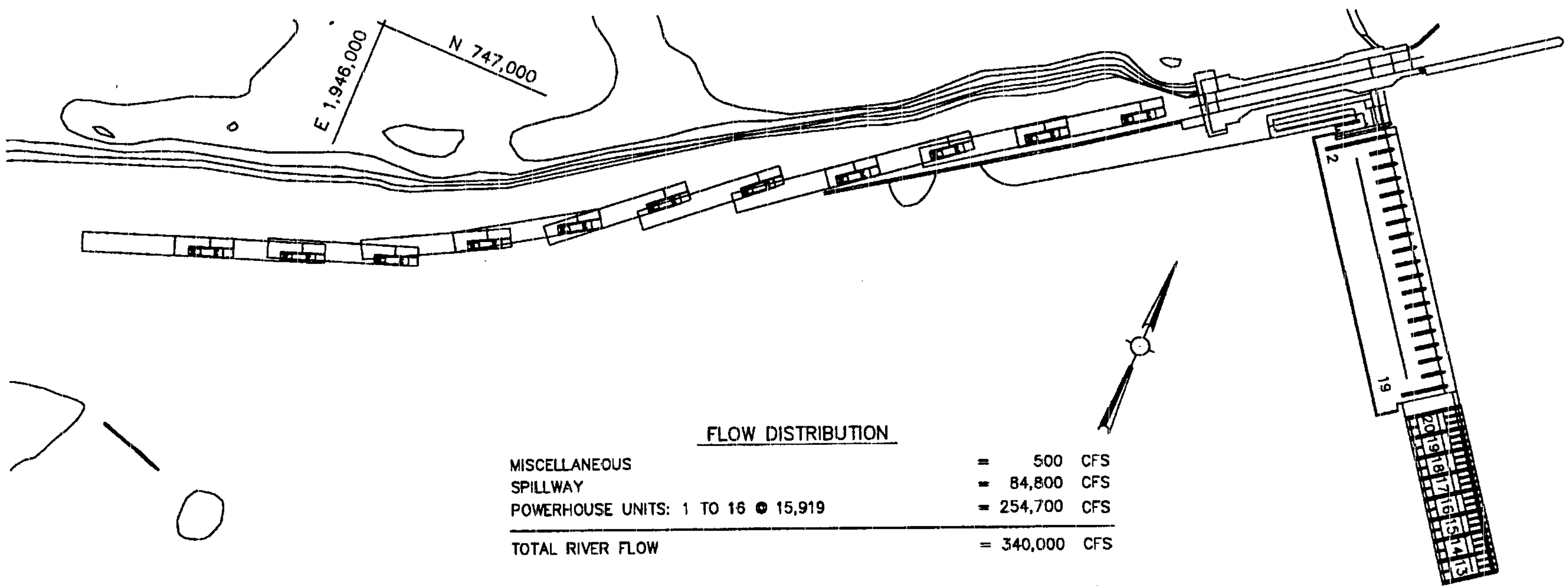
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
EXITING LOCK
1998 SPILL PATTERN
DISCHARGE: 325,000 CFS
LOWER POOL EL: 163.7 FT

JD-229



FLOW DISTRIBUTION

MISCELLANEOUS	= 500 CFS
SPILLWAY	= 84,800 CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,919	= 254,700 CFS
TOTAL RIVER FLOW	= 340,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	5	5	4	4	4	3	3	3	3	3	2	2	2	2	2	2	1	●	●

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

SCALES IN FEET

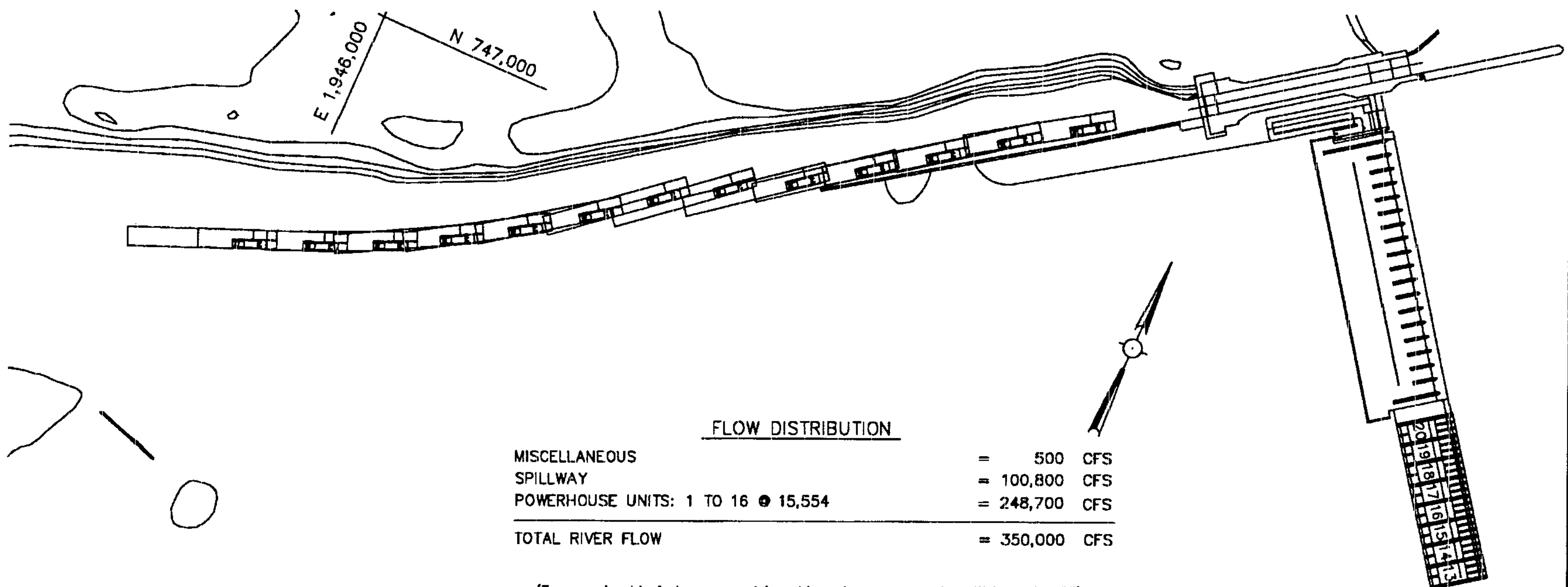
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
EXITING LOCK
1998 SPILL PATTERN
DISCHARGE: 340,000 CFS
LOWER POOL EL: 164.1 FT

JD-203



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 100,800	CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,554	= 248,700	CFS
TOTAL RIVER FLOW	= 350,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	3	5	5	5	5	4	4	4	4	3	3	3	3	3	3	3	2	1	●	●

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

SCALES IN FEET

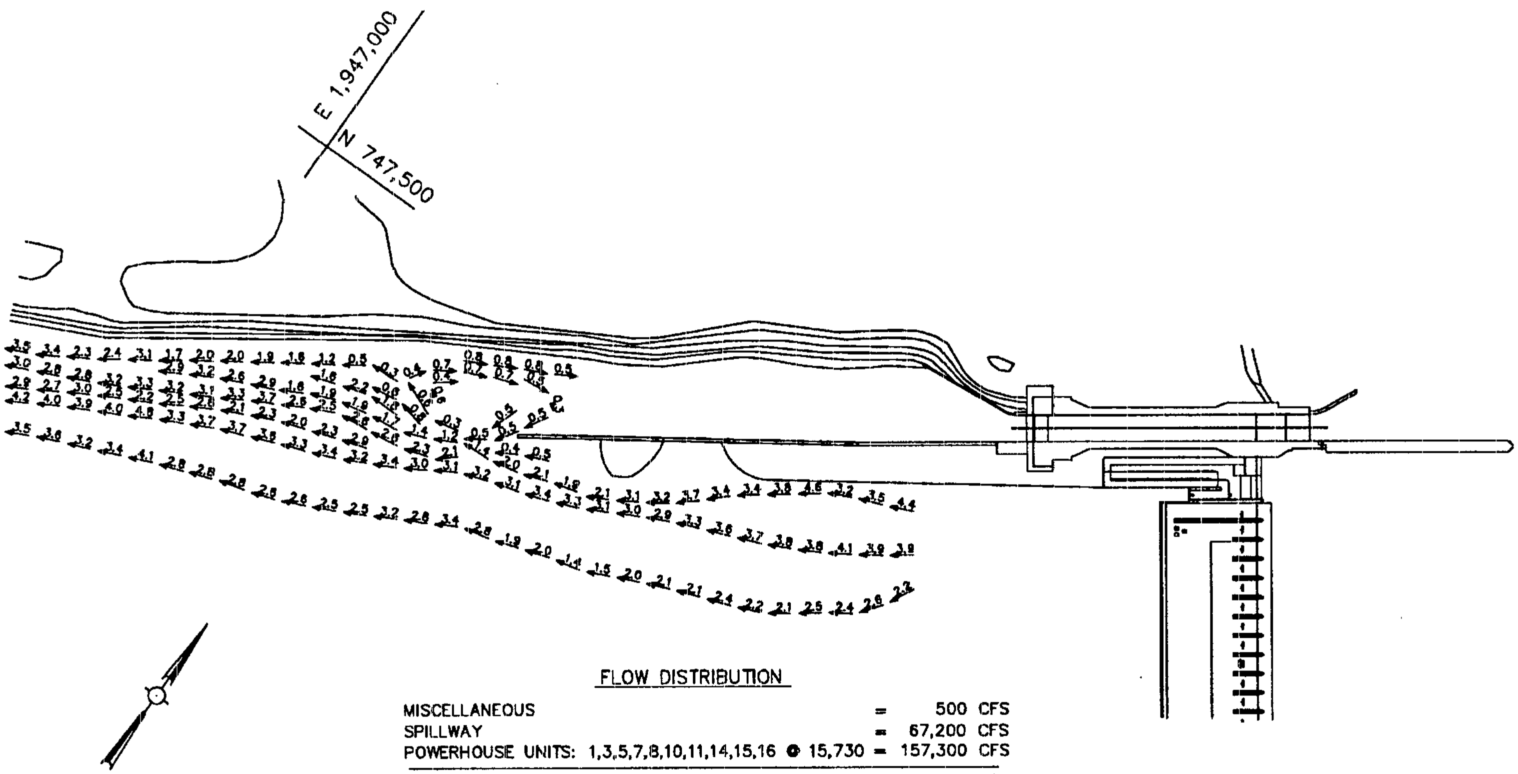
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
EXITING LOCK
1998 SPILL PATTERN
DISCHARGE: 350,000 CFS
LOWER POOL EL: 164.4 FT

JDAY--199



FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	67,200 CFS
POWERHOUSE UNITS: 1,3,5,7,8,10,11,14,15,16 @ 15,730	=	157,300 CFS
TOTAL RIVER FLOW	=	225,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	2	4	4	3	3	3	3	3	2	2	2	2	2	2	2	2	1	●	●	●

SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

LEGEND

1.0 VELOCITY IN FEET PER SECOND (To convert feet per second to meters per second, multiply by 0.3048)

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 1 TO 20

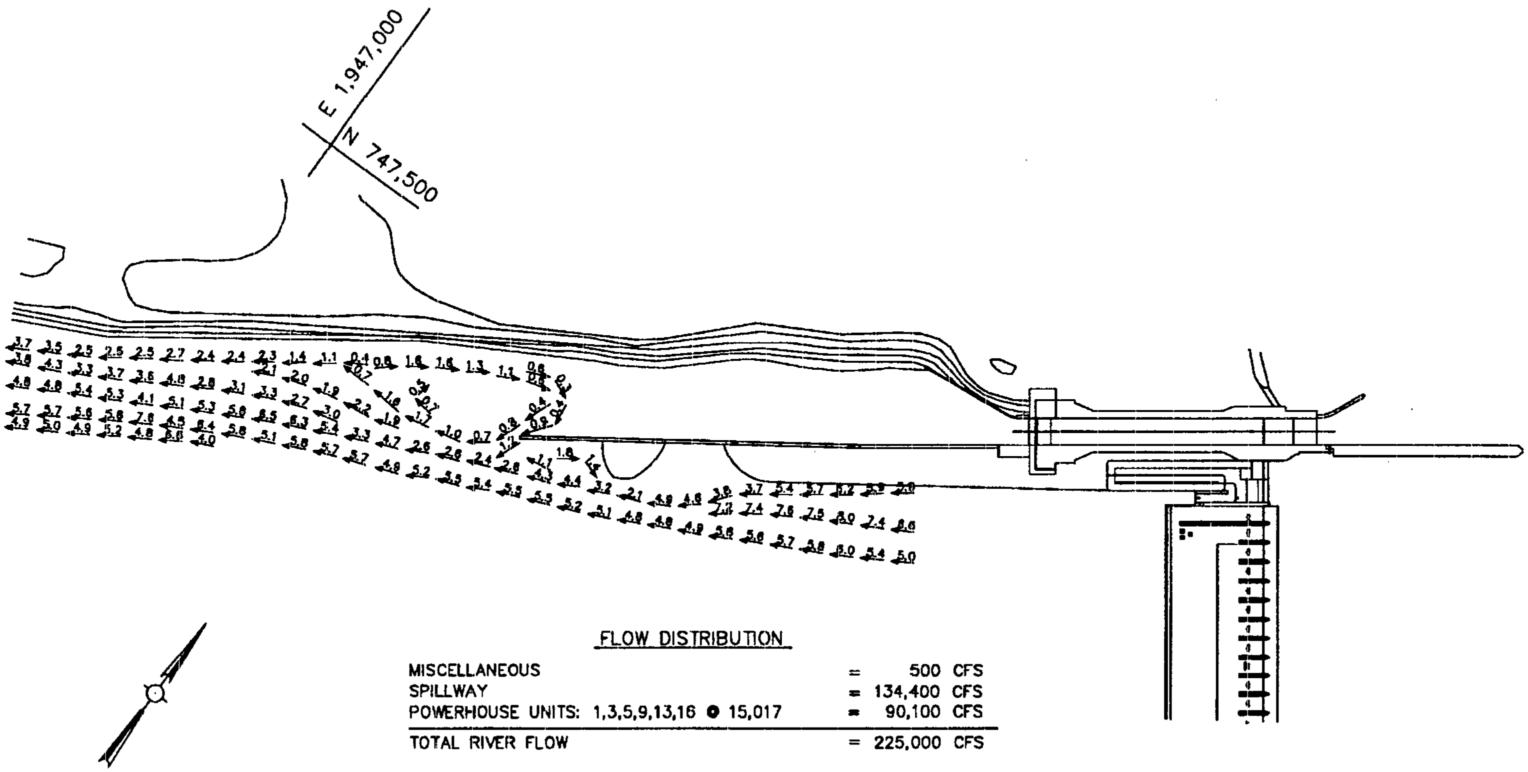
VELOCITIES AND CURRENT DIRECTIONS

1999 SPILL PATTERN

VELOCITIES AT 14 FT

DISCHARGE: 225,000 CFS

LOWER POOL EL: 161.2 FT



FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	134,400 CFS
POWERHOUSE UNITS: 1,3,5,9,13,16 ● 15,017	=	90,100 CFS
TOTAL RIVER FLOW	=	225,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	2	1

SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

LEGEND

1.0 VELOCITY IN FEET PER SECOND (To convert feet per second to meters per second, multiply by 0.3048)

● INDICATES SPILLWAY GATES CLOSED

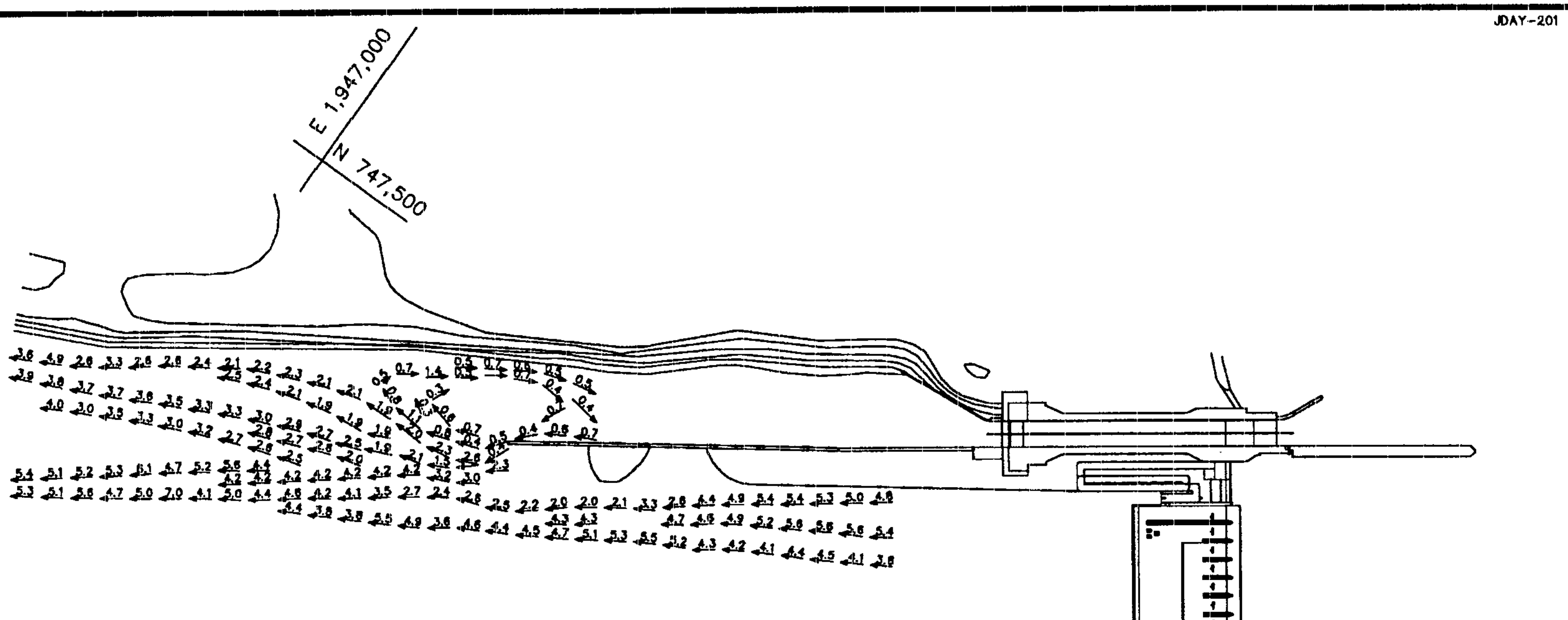
NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 1 TO 20

VELOCITIES AND
CURRENT DIRECTIONS

1999 SPILL PATTERN
VELOCITIES AT 14 FT

DISCHARGE: 225,000 CFS
LOWER POOL EL: 161.2 FT



FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	148,800 CFS
POWERHOUSE UNITS: 1,2,3,5,6,9 TO 16 @ 13,515	=	175,700 CFS
TOTAL RIVER FLOW	=	325,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	2	1

LEGEND

1.0 VELOCITY IN FEET PER SECOND (To convert feet per second to meters per second, multiply by 0.3048)

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 1 TO 20

SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

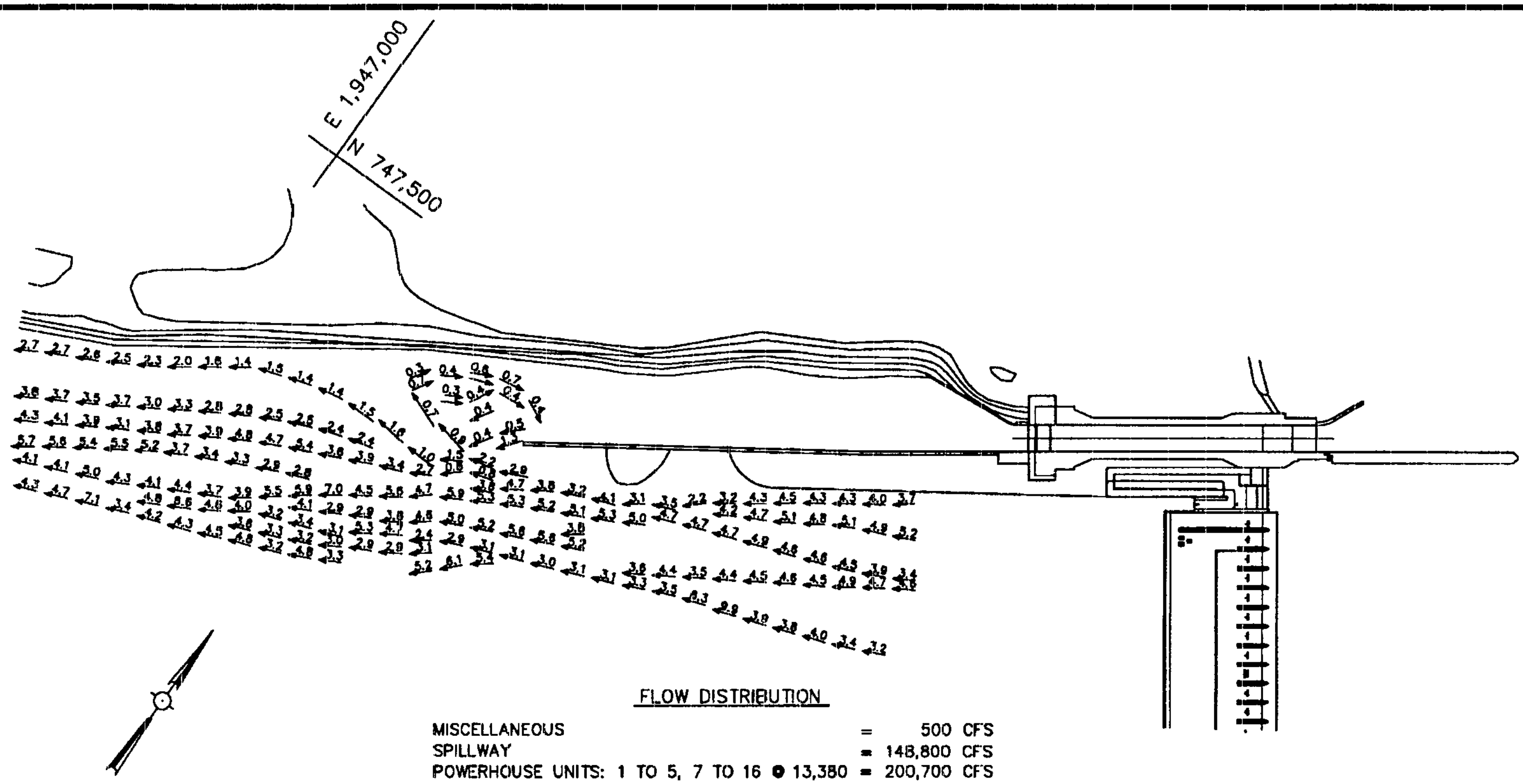
VELOCITIES AND CURRENT DIRECTIONS

1999 SPILL PATTERN

VELOCITIES AT 14 FT

DISCHARGE: 325,000 CFS

LOWER POOL EL: 163.7 FT



FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	148,800 CFS
POWERHOUSE UNITS: 1 TO 5, 7 TO 16 @ 13,380	=	200,700 CFS
TOTAL RIVER FLOW	=	350,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	2	1

SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

LEGEND

1.0 VELOCITY IN FEET PER SECOND (To convert feet per second to meters per second, multiply by 0.3048)

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 1 TO 20

VELOCITIES AND CURRENT DIRECTIONS

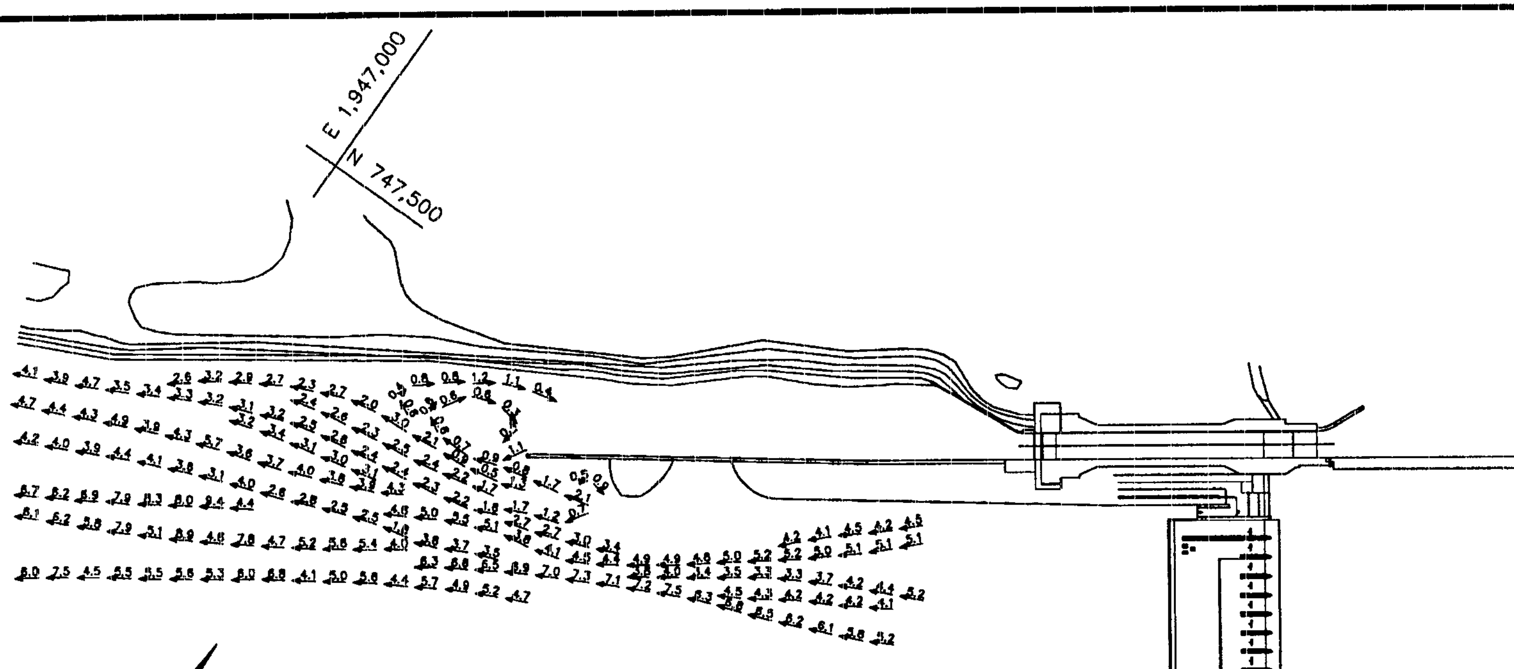
1999 SPILL PATTERN

VELOCITIES AT 14 FT

DISCHARGE: 350,000 CFS

LOWER POOL EL: 164.4 FT

JDAY--197



FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	174,400 CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,631	=	250,100 CFS
TOTAL RIVER FLOW	=	425,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	5	5	3	2

SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

LEGEND

1.0 VELOCITY IN FEET PER SECOND
(To convert feet per second to meters per second, multiply by 0.3048)

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 1 TO 20

VELOCITIES AND CURRENT DIRECTIONS

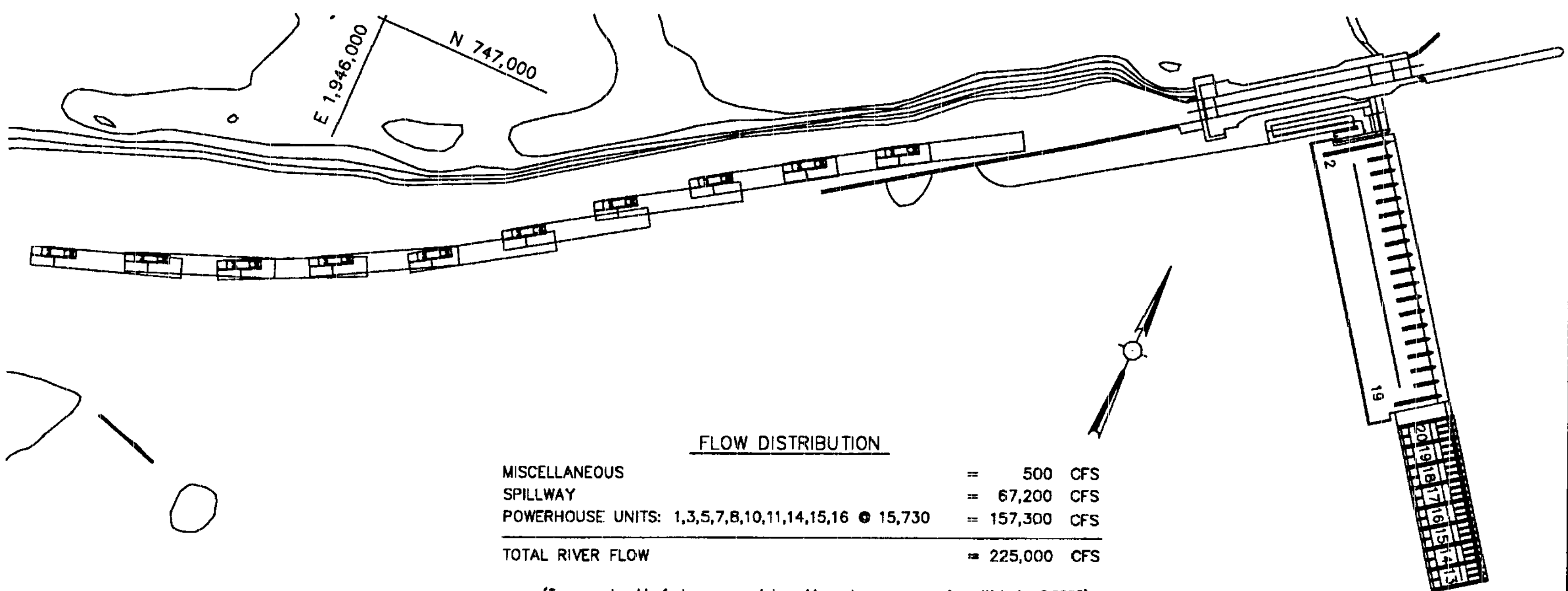
1999 SPILL PATTERN

VELOCITIES AT 14 FT

DISCHARGE: 425,000 CFS

LOWER POOL EL: 166.3 FT

JD-232



FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	67,200 CFS
POWERHOUSE UNITS: 1,3,5,7,8,10,11,14,15,16 @ 15,730	=	157,300 CFS
TOTAL RIVER FLOW	=	225,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	2	4	4	3	3	3	3	3	2	2	2	2	2	2	2	2	1	●	●	●

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 1 TO 20

SCALES IN FEET

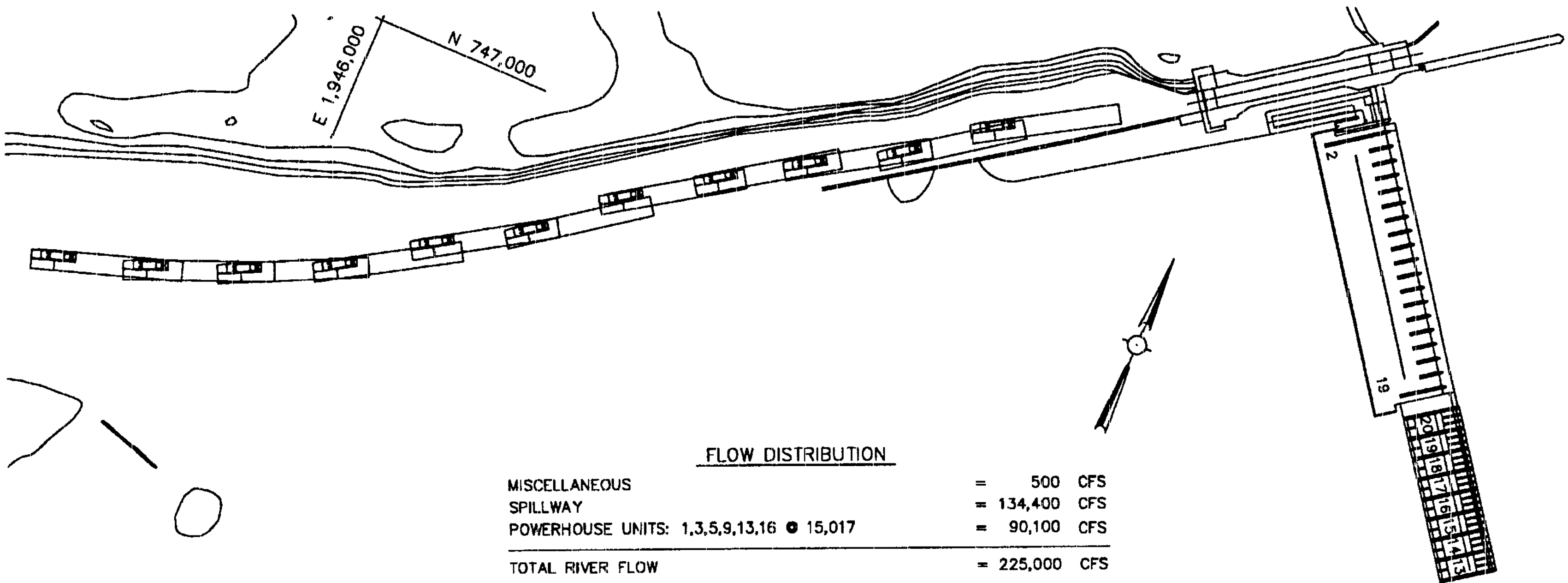
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
ENTERING LOCK
1999 SPILL PATTERN
DISCHARGE: 225,000 CFS
LOWER POOL EL: 161.2 FT

JD-231



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 134,400	CFS
POWERHOUSE UNITS: 1,3,5,9,13,16 @ 15,017	= 90,100	CFS
TOTAL RIVER FLOW	= 225,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	2	1

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 1 TO 20

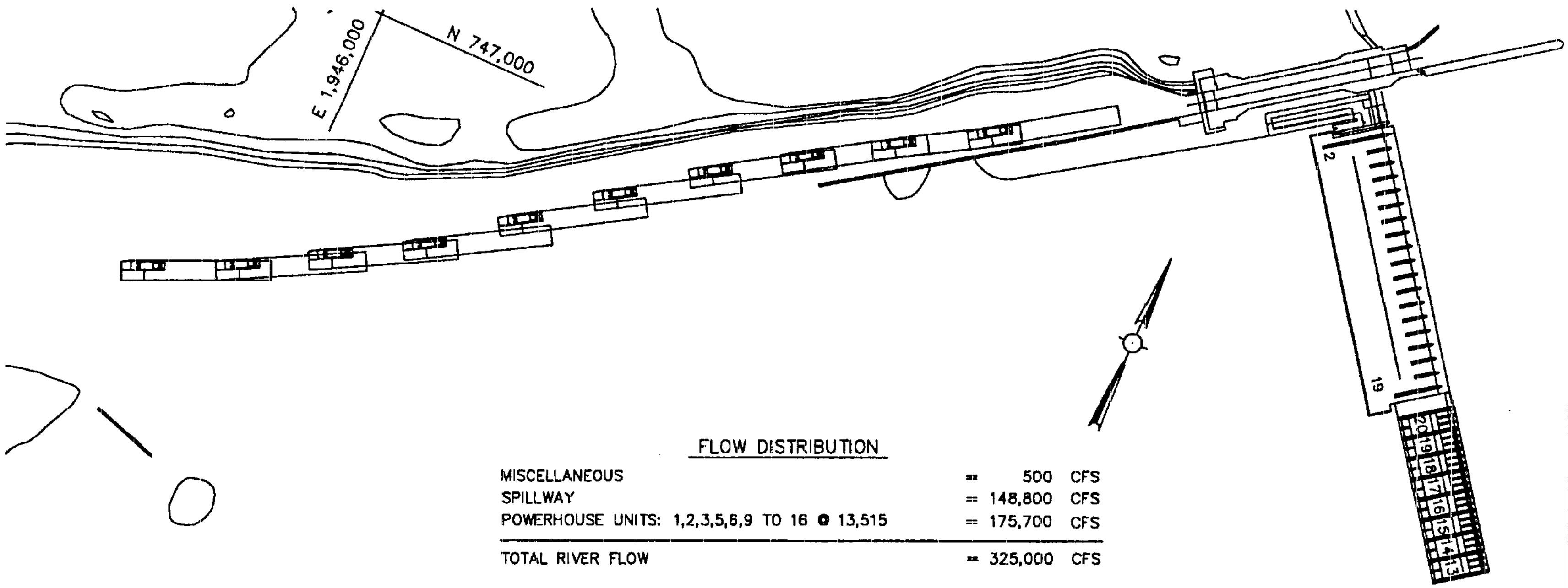
SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
ENTERING LOCK
1999 SPILL PATTERN
DISCHARGE: 225,000 CFS
LOWER POOL EL: 161.2 FT



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 148,800	CFS
POWERHOUSE UNITS: 1,2,3,5,6,9 TO 16 @ 13,515	= 175,700	CFS
TOTAL RIVER FLOW	= 325,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	2	1

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 1 TO 20

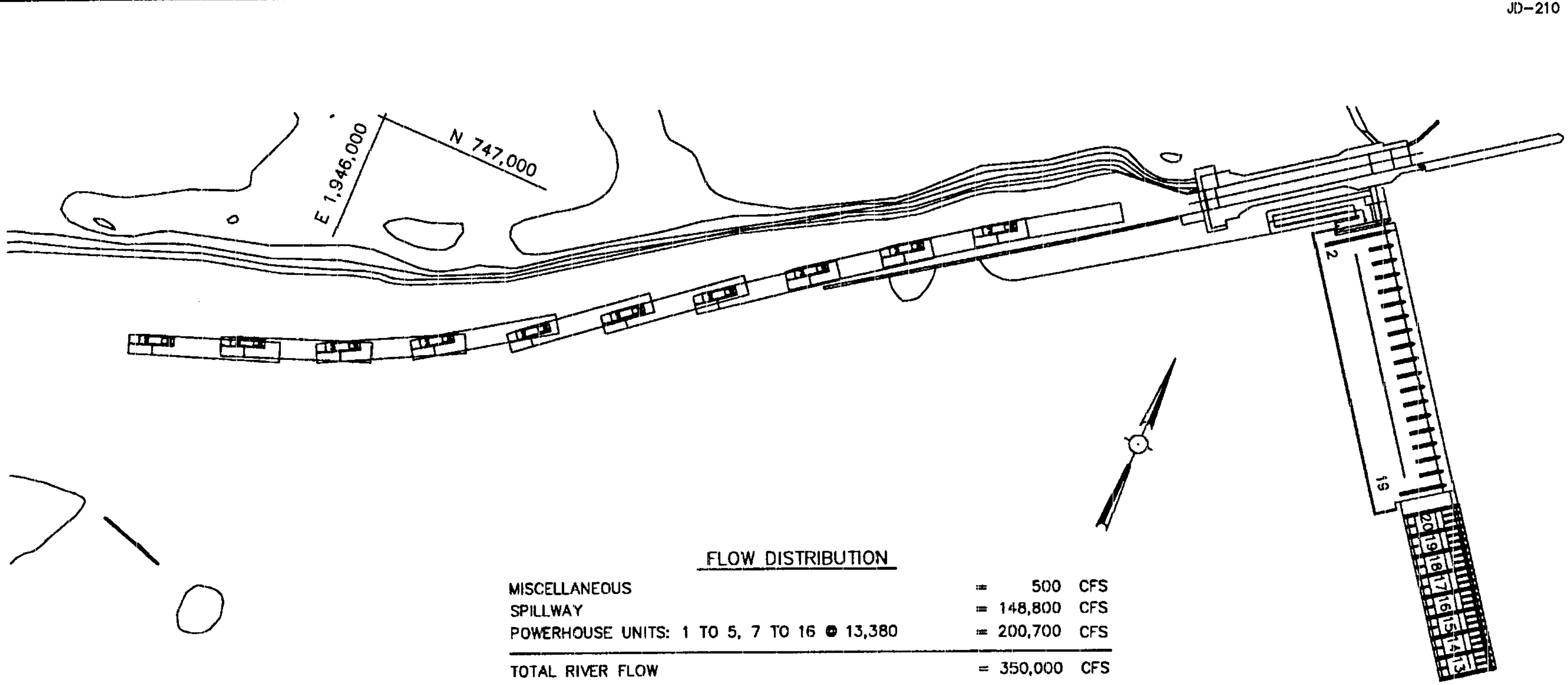
SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
ENTERING LOCK
1999 SPILL PATTERN
DISCHARGE: 325,000 CFS
LOWER POOL EL: 163.7 FT



FLOW DISTRIBUTION

MISCELLANEOUS	= 500 CFS
SPILLWAY	= 148,800 CFS
POWERHOUSE UNITS: 1 TO 5, 7 TO 16 @ 13,380	= 200,700 CFS
TOTAL RIVER FLOW	= 350,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	2	1

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 1 TO 20

SCALES IN FEET

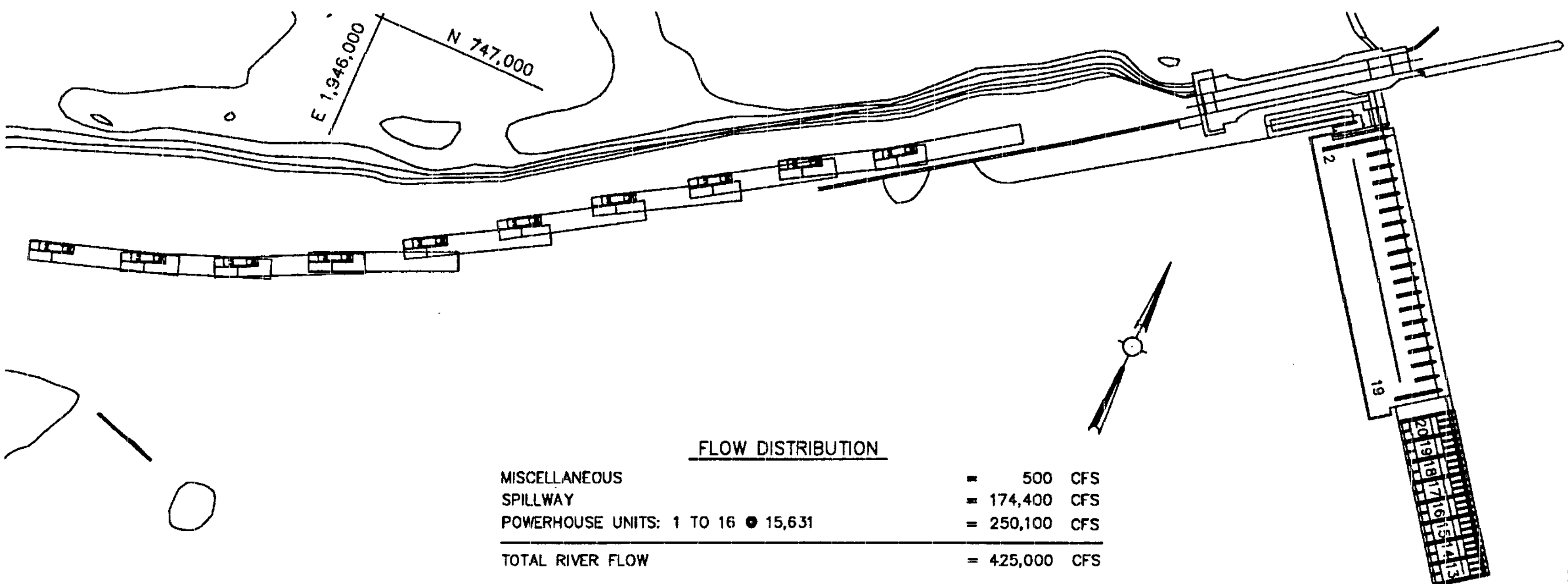
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
ENTERING LOCK
1999 SPILL PATTERN
DISCHARGE: 350,000 CFS
LOWER POOL EL: 164.4 FT

JD-235



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 174,400	CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,631	= 250,100	CFS
TOTAL RIVER FLOW	= 425,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	5	5	3	2

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 1 TO 20

SCALES IN FEET

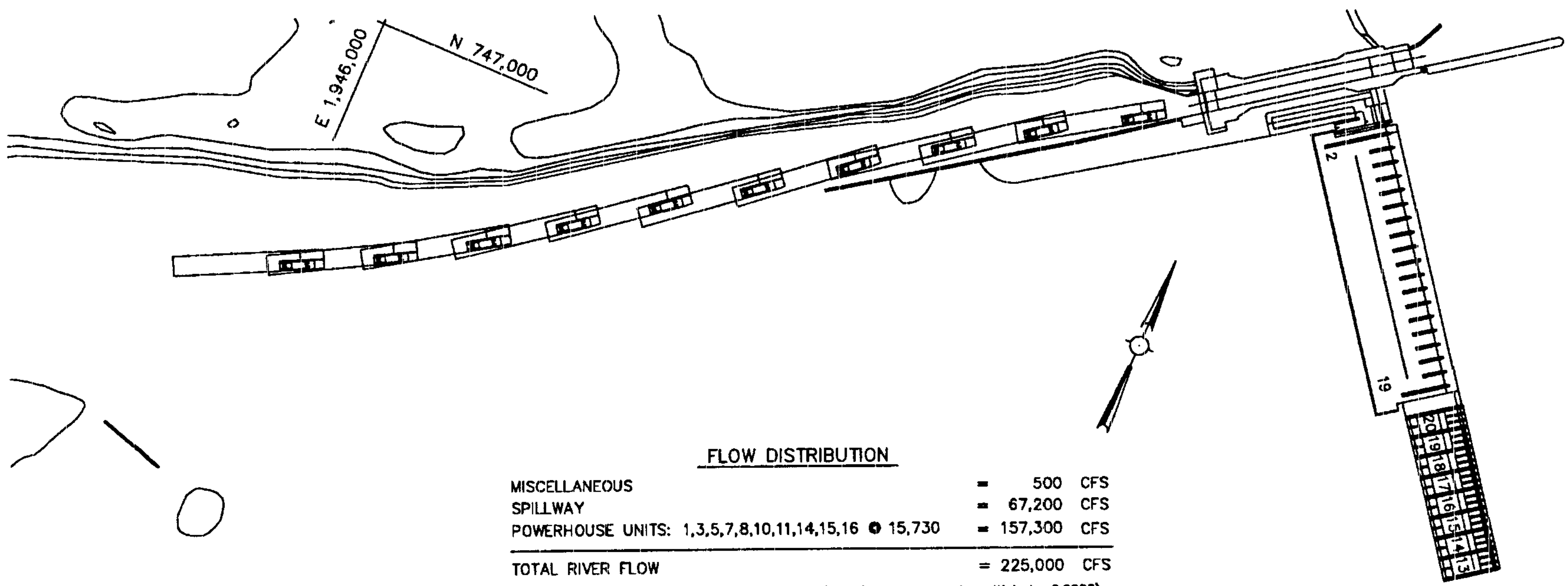
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
ENTERING LOCK
1999 SPILL PATTERN
DISCHARGE: 425,000 CFS
LOWER POOL EL: 166.3 FT

JD-233



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 67,200	CFS
POWERHOUSE UNITS: 1,3,5,7,8,10,11,14,15,16 @ 15,730	= 157,300	CFS
TOTAL RIVER FLOW	= 225,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	2	4	4	3	3	3	3	3	2	2	2	2	2	2	2	2	1	●	●	●

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 1 TO 20

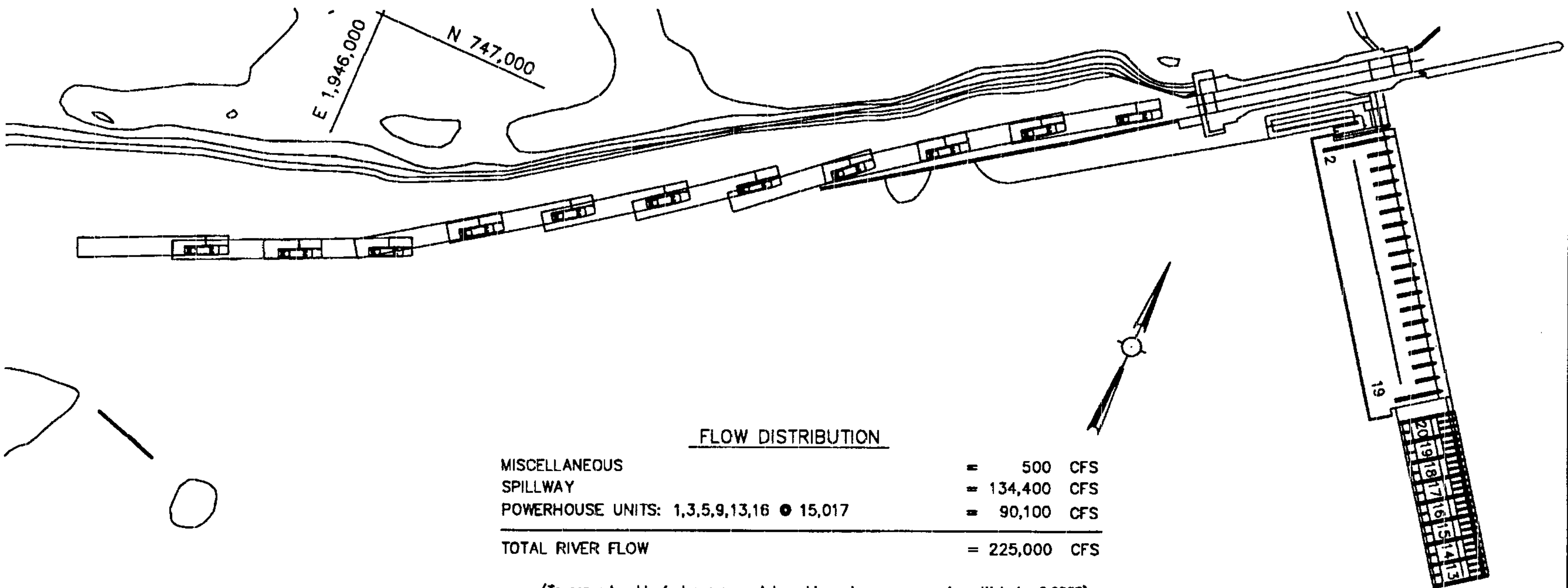
SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
EXITING LOCK
1999 SPILL PATTERN
DISCHARGE: 225,000 CFS
LOWER POOL EL: 161.2 FT



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 134,400	CFS
POWERHOUSE UNITS: 1,3,5,9,13,16 ● 15,017	= 90,100	CFS
TOTAL RIVER FLOW	= 225,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	2	1

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 1 TO 20

SCALES IN FEET

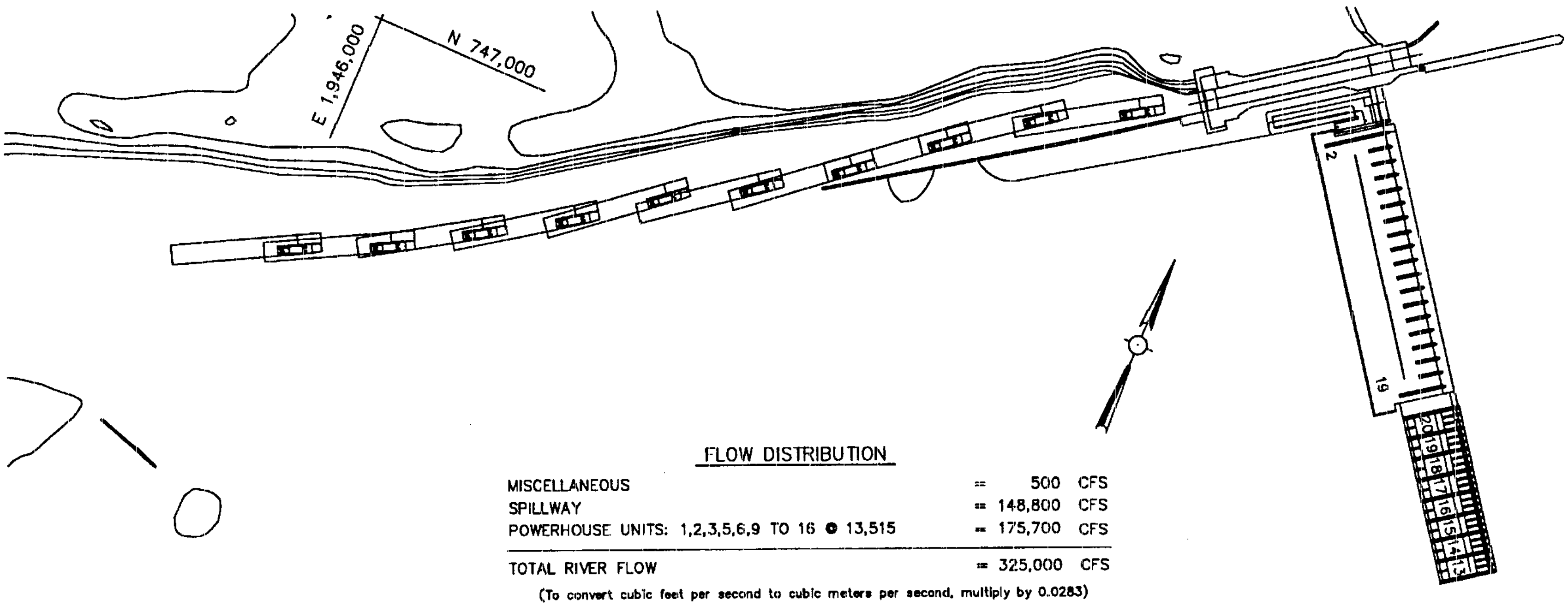
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
EXITING LOCK
1999 SPILL PATTERN
DISCHARGE: 225,000 CFS
LOWER POOL EL: 161.2 FT

JD-220



FLOW DISTRIBUTION

MISCELLANEOUS	= 500 CFS
SPILLWAY	= 148,800 CFS
POWERHOUSE UNITS: 1,2,3,5,6,9 TO 16 @ 13,515	= 175,700 CFS
TOTAL RIVER FLOW	= 325,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	2	1

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 1 TO 20

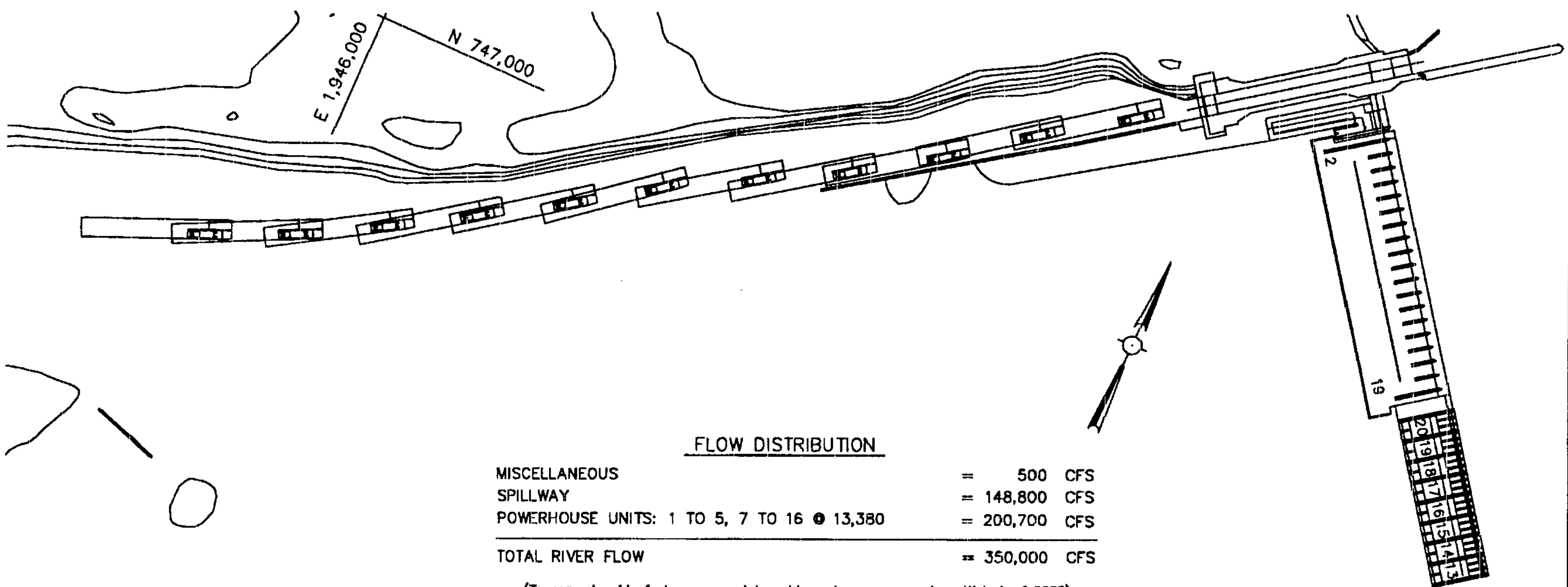
SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
EXITING LOCK
1999 SPILL PATTERN
DISCHARGE: 325,000 CFS
LOWER POOL EL: 163.7 FT



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 148,800	CFS
POWERHOUSE UNITS: 1 TO 5, 7 TO 16 @ 13,380	= 200,700	CFS
TOTAL RIVER FLOW	= 350,000	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	2	1

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 1 TO 20

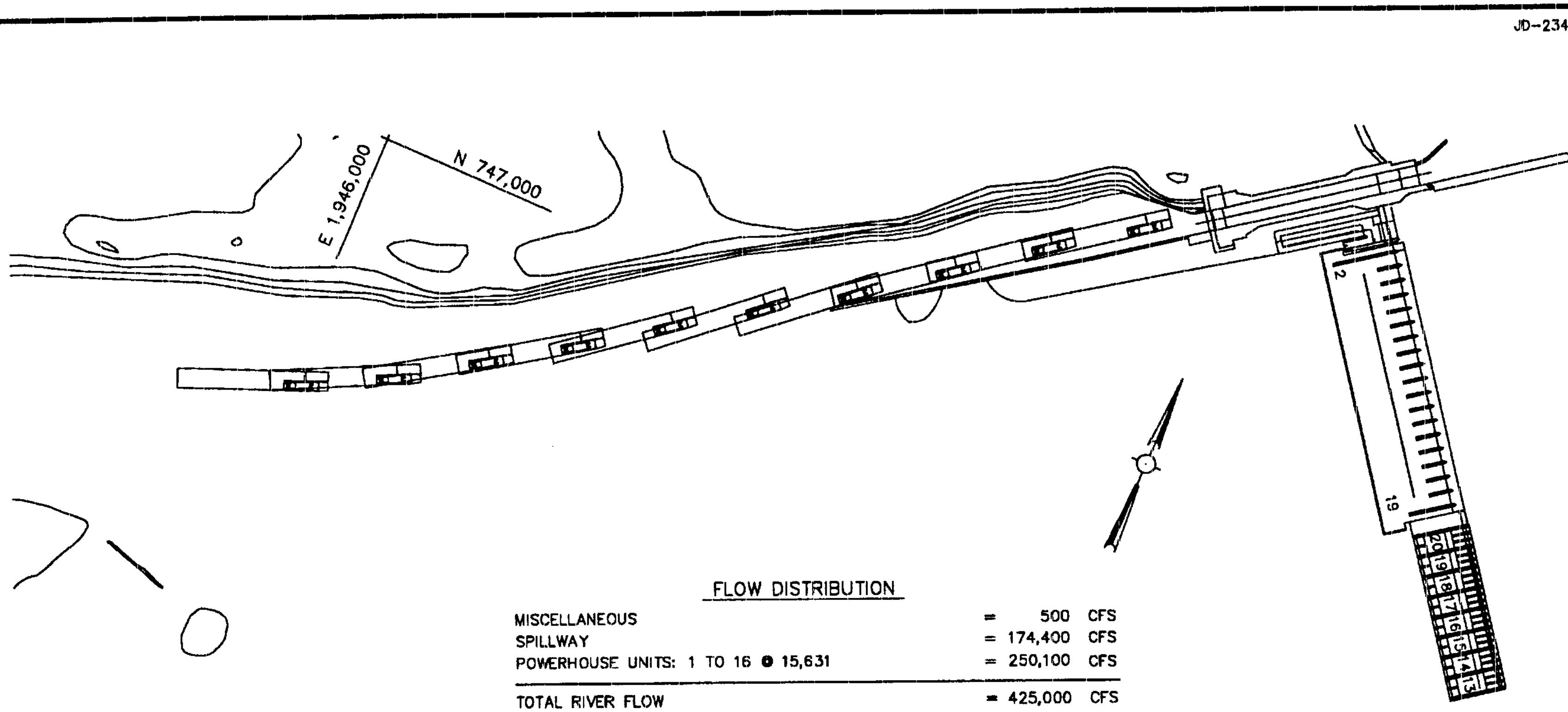
SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
EXITING LOCK
1999 SPILL PATTERN
DISCHARGE: 350,000 CFS
LOWER POOL EL: 164.4 FT



FLOW DISTRIBUTION

MISCELLANEOUS	= 500 CFS
SPILLWAY	= 174,400 CFS
POWERHOUSE UNITS: 1 TO 16 @ 15,631	= 250,100 CFS
TOTAL RIVER FLOW	= 425,000 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	5	5	3	2

LEGEND

84 FT X 650 FT

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 1 TO 20

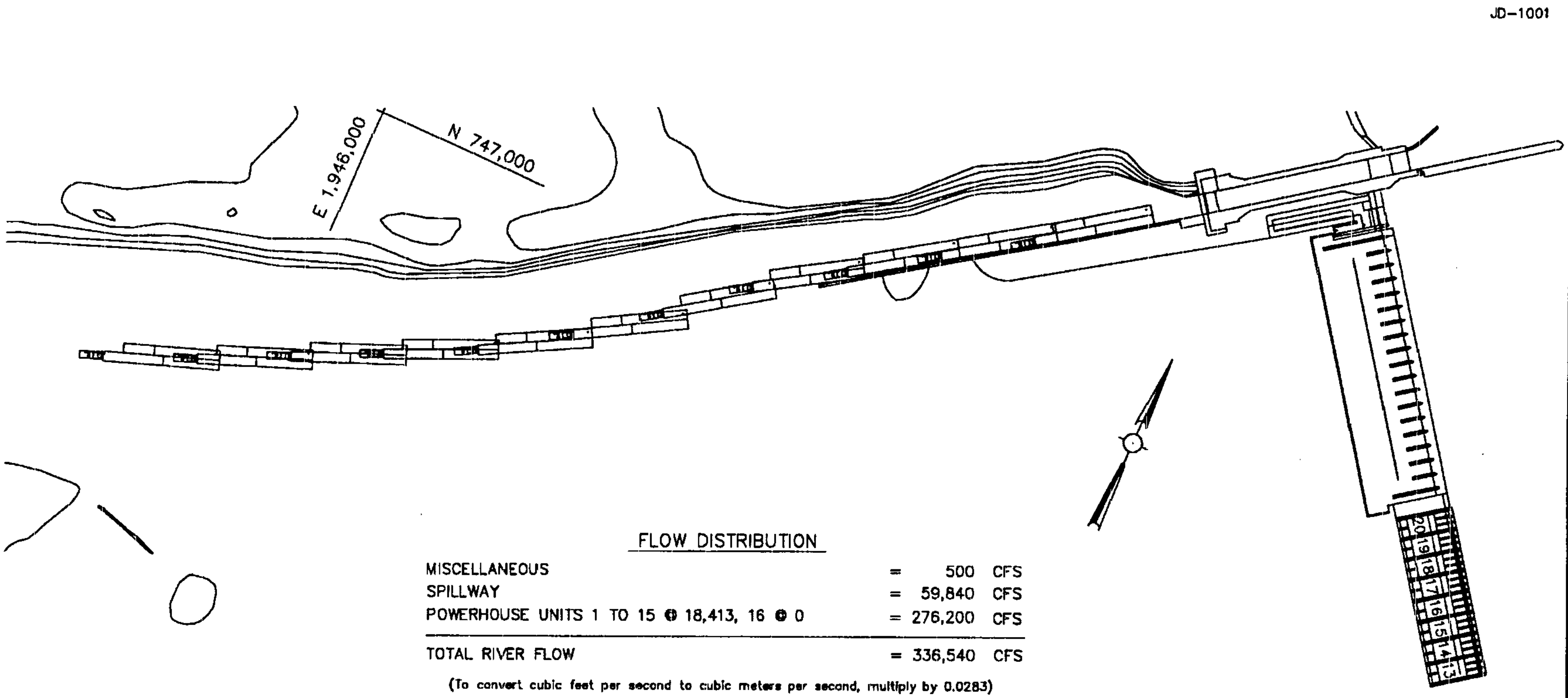
SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

TOW PATH
EXITING LOCK
1999 SPILL PATTERN
DISCHARGE: 425,000 CFS
LOWER POOL EL: 166.3 FT



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 59,840	CFS
POWERHOUSE UNITS 1 TO 15 @ 18,413, 16 @ 0	= 276,200	CFS
TOTAL RIVER FLOW	= 336,540	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	1.9	2.9	3.0	2.8	2.9	2.8	3.0	3.0	1.9	2.0	2.0	2.0	2.1	2.0	2.1	1.0	●	●	●	●

LEGEND

TOW CONFIGURATION

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

SCALES IN FEET

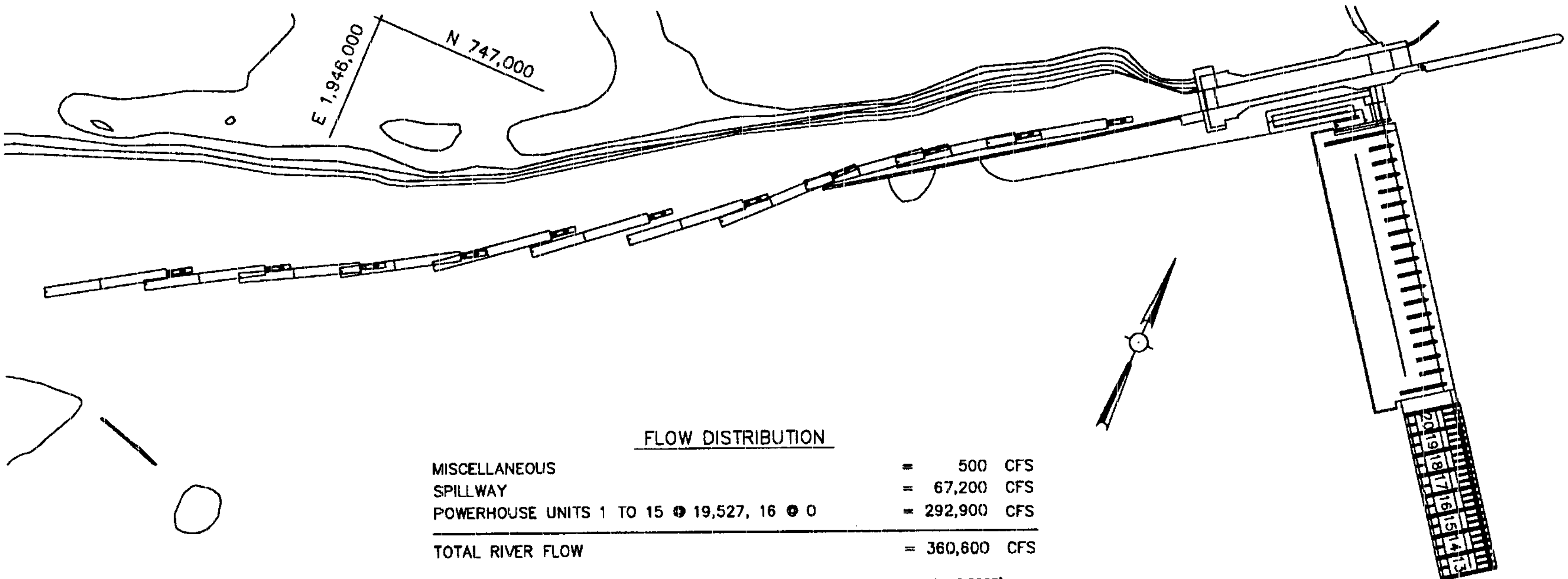
PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

PROTOTYPE TOW TRACK
ENTERING LOCK
M/V OUTLAW
JUNE 22, 1999
DISCHARGE: 336,540 CFS
LOWER POOL EL: 165.5 FT

JD-1002



FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	67,200 CFS
POWERHOUSE UNITS 1 TO 15 @ 19,527, 16 @ 0	=	292,900 CFS
TOTAL RIVER FLOW	=	360,600 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	1.9	3.8	3.9	3.8	3.9	2.8	3.0	3.0	2.9	2.0	2.0	2.0	2.1	2.0	2.1	2.0	1.1	●	●	●

LEGEND

TOW CONFIGURATION

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

SCALES IN FEET

PROTOTYPE 0 400 800

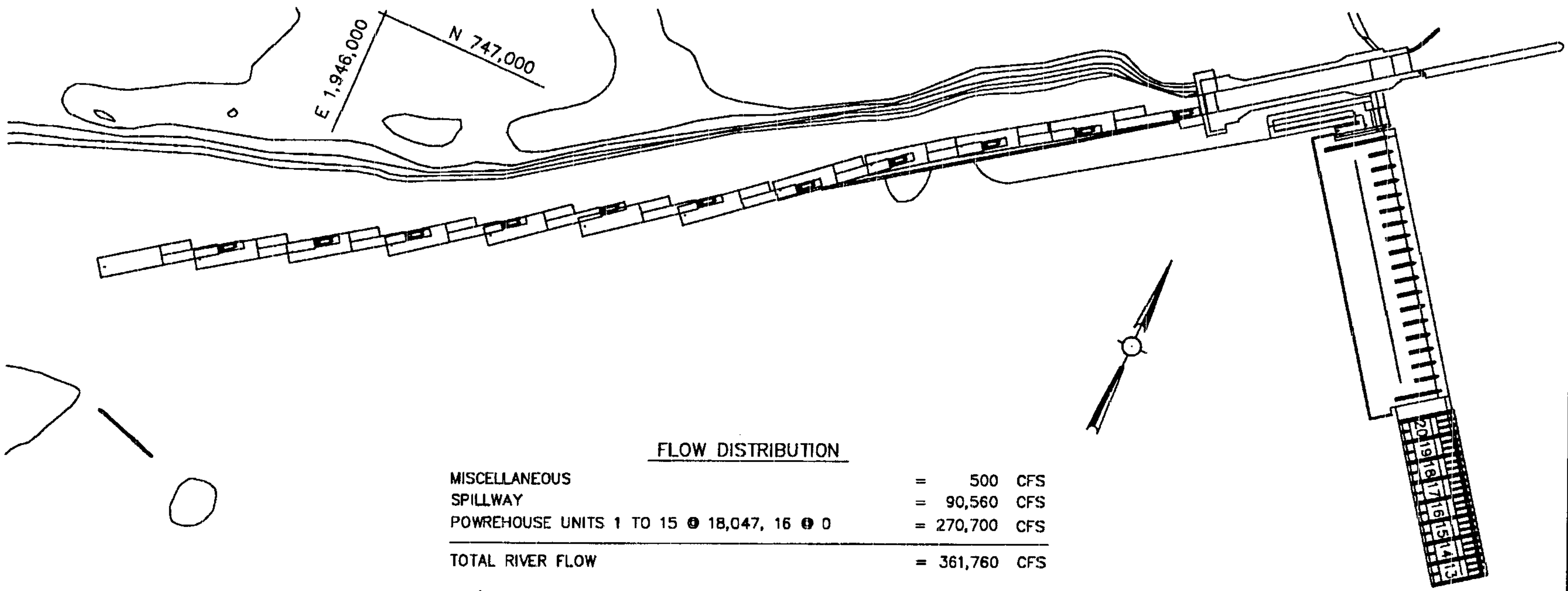
MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

PROTOTYPE TOW TRACK
EXITING LOCK
M/V KATHERINE B
JUNE 23, 1999

DISCHARGE: 360,600 CFS
LOWER POOL EL: 164.8 FT

JD-1003



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 90,560	CFS
POWREHOUSE UNITS 1 TO 15 @ 18,047, 16 @ 0	= 270,700	CFS
TOTAL RIVER FLOW	= 361,760	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	2.9	4.8	4.9	4.8	3.9	3.8	4.0	3.0	2.9	3.0	3.1	2.9	2.9	3.0	1.7	2.0	2.1	.9	●	●

LEGEND

TOW CONFIGURATION

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

SCALES IN FEET

PROTOTYPE 0 400 800

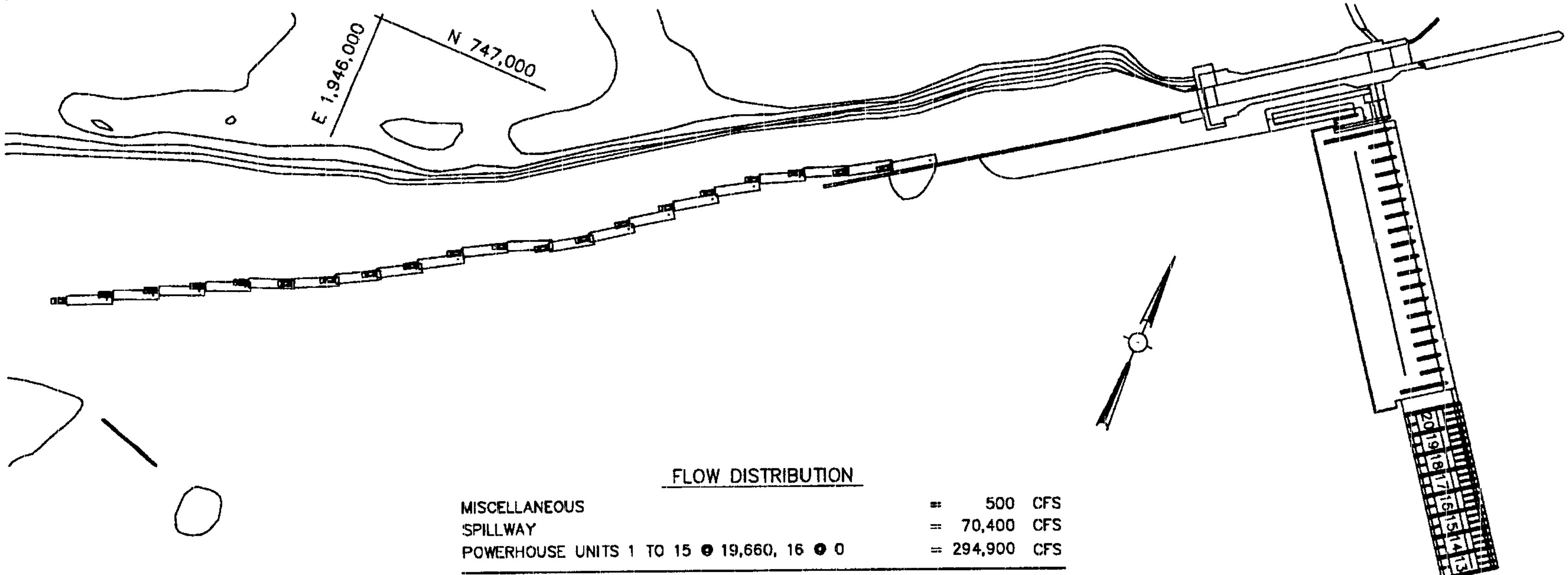
MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

PROTOTYPE TOW TRACK
EXITING LOCK
M/V CHALLANGER
JUNE 23, 1999

DISCHARGE: 361,760 CFS
LOWER POOL EL: 165.6 FT

JD-1004



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 70,400	CFS
POWERHOUSE UNITS 1 TO 15 @ 19,660, 16 @ 0	= 294,900	CFS
TOTAL RIVER FLOW	= 365,800	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	1.9	3.9	4.0	3.9	3.9	2.9	3.0	3.0	2.9	2.0	2.0	1.9	2.0	2.0	1.7	2.0	1.0	●	●	●

LEGEND

TOW CONFIGURATION

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

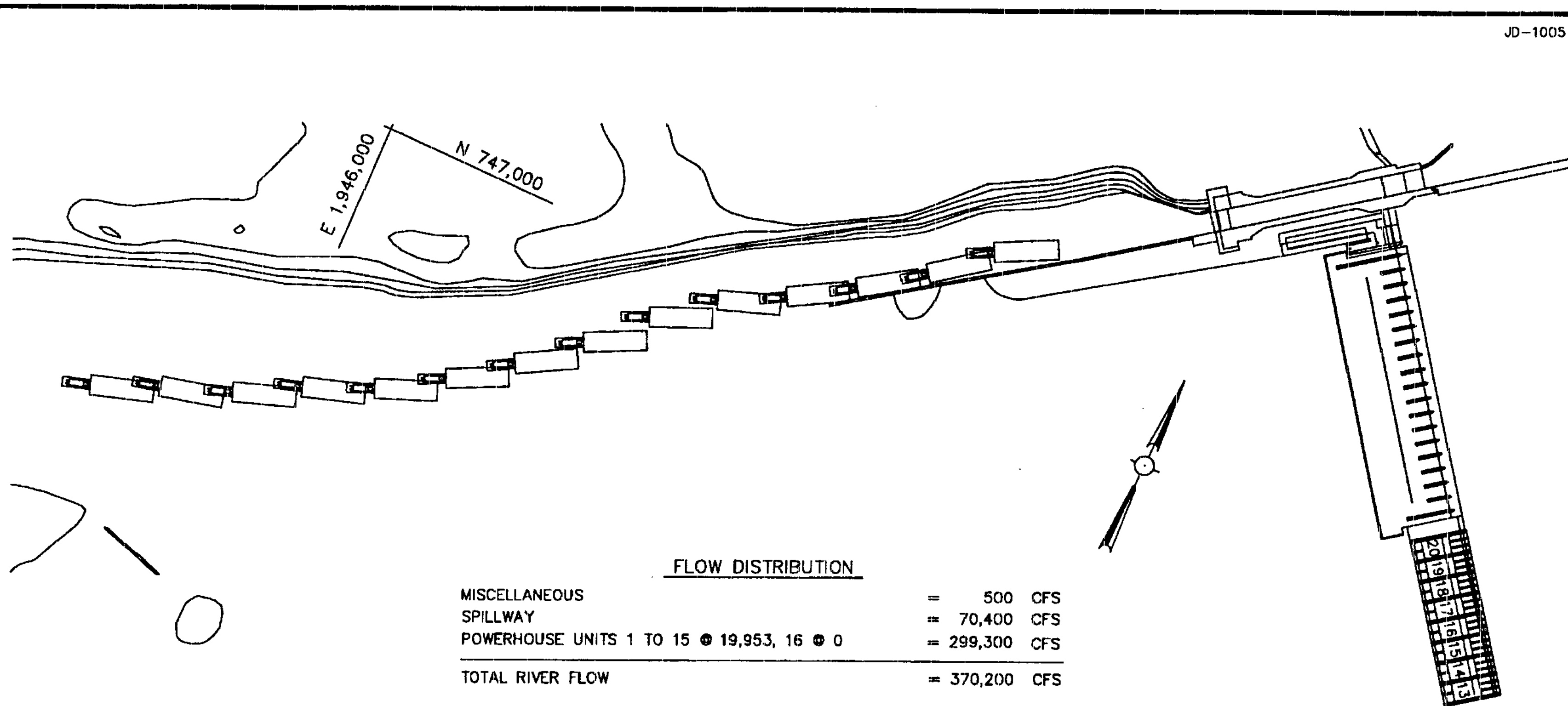
SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

PROTOTYPE TOW TRACK
ENTERING LOCK
M/V MARY B
JUNE 23, 1999
DISCHARGE: 365,800 CFS
LOWER POOL EL: 165.6 FT



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 70,400	CFS
POWERHOUSE UNITS 1 TO 15 @ 19,953, 16 @ 0	= 299,300	CFS
TOTAL RIVER FLOW	= 370,200	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	1.9	3.9	4.0	3.9	3.9	2.9	3.0	3.0	2.9	2.0	2.0	1.9	2.0	2.0	1.7	2.0	1.0	●	●	●

LEGEND

TOW CONFIGURATION

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

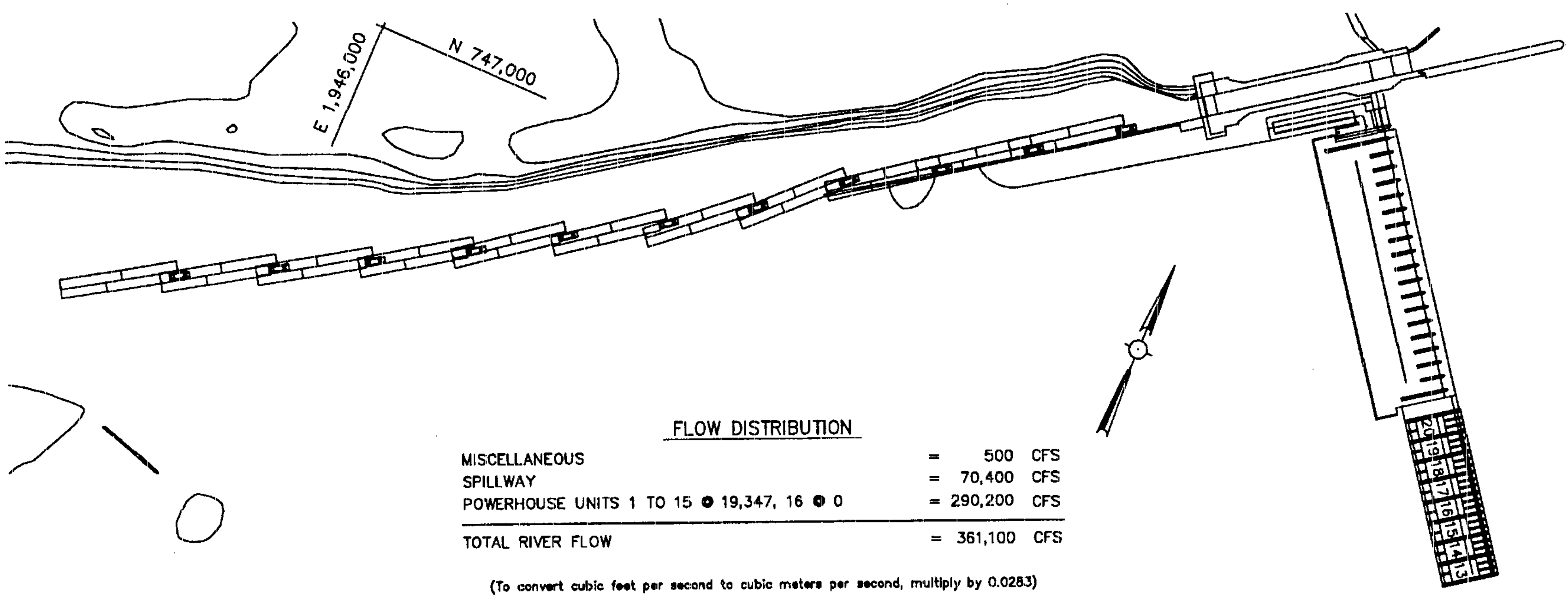
SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

PROTOTYPE TOW TRACK
ENTERING LOCK
M/V CHIEF
JUNE 23, 1999
DISCHARGE: 370,200 CFS
LOWER POOL EL: 165.8 FT



FLOW DISTRIBUTION

MISCELLANEOUS	= 500	CFS
SPILLWAY	= 70,400	CFS
POWERHOUSE UNITS 1 TO 15 @ 19,347, 16 @ 0	= 290,200	CFS
TOTAL RIVER FLOW	= 361,100	CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
GATE OPENING IN STOPS	1.9	3.9	4.0	3.9	3.9	2.9	3.0	3.0	2.9	2.0	2.0	1.9	2.0	2.0	1.7	2.0	1.0	●	●	●

LEGEND

TOW CONFIGURATION

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

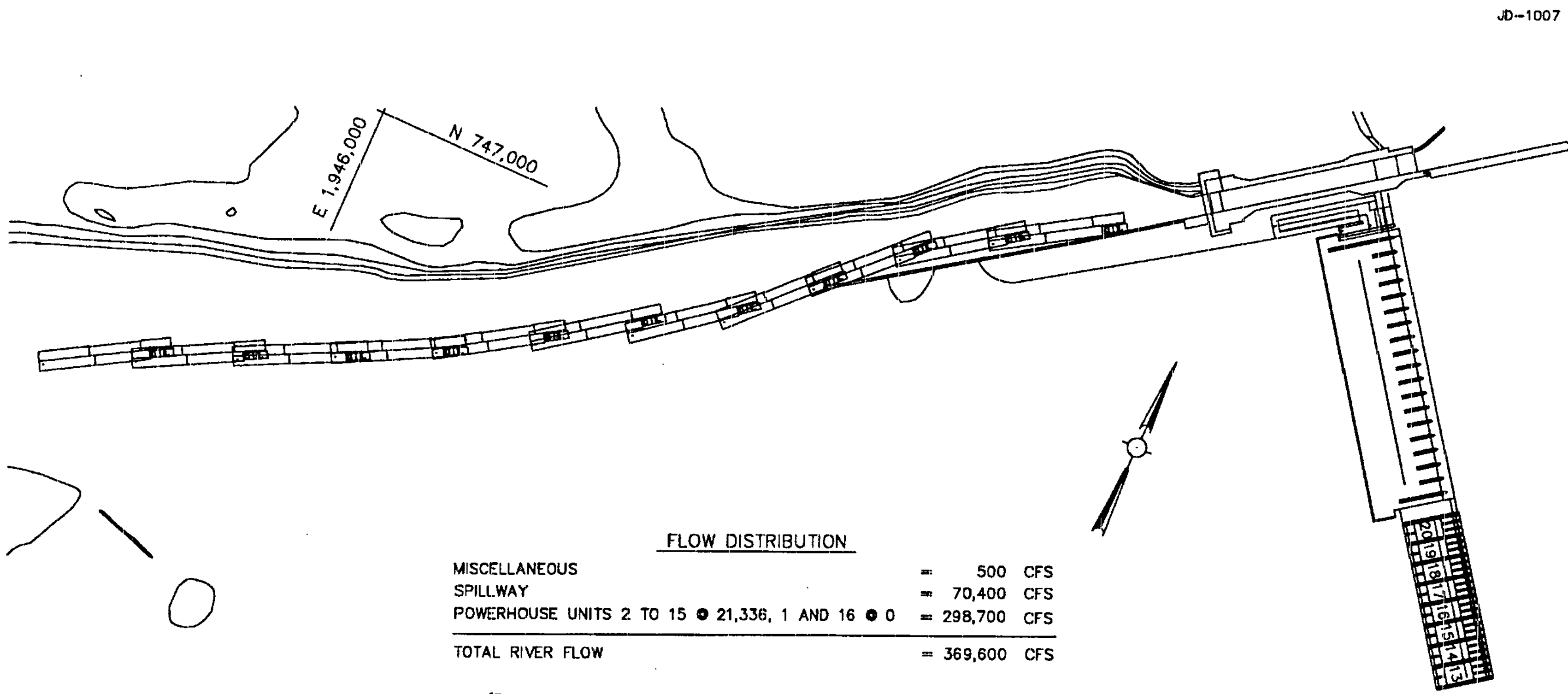
SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

PROTOTYPE TOW TRACK
EXITING LOCK
M/V CLARKSTON
JUNE 24, 1999
DISCHARGE: 361,100 CFS
LOWER POOL EL: 165.8 FT



FLOW DISTRIBUTION

MISCELLANEOUS	=	500 CFS
SPILLWAY	=	70,400 CFS
POWERHOUSE UNITS 2 TO 15 @ 21,336, 1 AND 16 @ 0	=	298,700 CFS
TOTAL RIVER FLOW	=	369,600 CFS

(To convert cubic feet per second to cubic meters per second, multiply by 0.0283)

SPILLWAY GATE PATTERN

BAY NO.	1	2	3	4	5	6	7	8	9	10	11	12	1.3	14	15	16	17	18	19	20
GATE OPENING IN STOPS	1.9	3.9	4.0	3.9	3.9	2.9	3.0	3.0	2.9	2.0	2.0	1.9	2.0	2.0	1.7	2.0	1.0	●	●	●

LEGEND

TOW CONFIGURATION

● INDICATES SPILLWAY GATES CLOSED

NOTE: ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

DEFLECTORS IN SPILLWAY GATES 2 TO 19

SCALES IN FEET

PROTOTYPE 0 400 800

MODEL 0 5 10

(To convert feet to meters, multiply by 0.3048)

PROTOTYPE TOW TRACK
EXITING LOCK
M/V OUTLAW
JUNE 24, 1999
DISCHARGE: 369,600 CFS
LOWER POOL EL: 165.5 FT

Appendix A
1997, 1998, and 1999 Spill Schedules

Tables A1 - A3 show the 1997, 1998, and 1999 spillway schedules for John Day Lock and Dam. These schedules were used when operating the model for collection of data in this report.

Table A1
1997 Spill Schedule for John Day Dam

Spillway Bay Numbers																					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	STOPS	KCFS
													1		1	1	1	1	1	6	9.6
															1	1	1	1	1	7	11.2
									1		1		1		1	1	1	1	1	8	12.8
							1		1		1		1		1	1	1	1	1	9	14.4
				1			1		1		1		1		1	1	1	1	1	10	16
	1			1			1		1		1		1		1	1	1	1	1	11	17.6
	1	1		1			1		1		1		1		1	1	1	1	1	12	19.2
	1			1			1		1		1		1		1	1	2	2	1	13	20.8
	1	1		1			1		1		1		1		1	1	2	2	1	14	22.4
	1	1		1			1		1		1		1	1	1	1	2	2	1	15	24
	1	1		1	1		1		1		1		1	1	1	1	2	2	1	16	25.6
	1	1		1			1		1		1		1		1	1	3.5	3.5	1	17	27.2
	1	1		1			1		1		1		1	1	1	1	3.5	3.5	1	18	28.8
	1	1		1	1		1		1		1		1	1	1	1	3.5	3.5	1	19	30.4
1	1	1		1	1		1		1		1		1	1	1	1	3.5	3.5	1	20	32
1	1	1	1	1	1		1		1		1		1	1	1	1	3.5	3.5	1	21	33.6
1	1	1		1	1		1		1		1		1	1	1	1	4.5	4.5	1	22	35.2
1	1	1	1	1	1		1		1		1		1	1	1	1	4.5	4.5	1	23	36.8
1	1	1	1	1	1		1		1		1	1	1	1	1	1	4.5	4.5	1	24	38.4
1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	4.5	4.5	1	25	40
1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	4.5	4.5	1	26	41.6
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4.5	4.5	4.5	27	43.2
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	4.5	4.5	4.5	28	44.8
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	4.5	4.5	4.5	29	46.4

(Sheet 1 of 4)

Table A1 (Continued)

Spillway Bay Numbers																				STOPS	KCFS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	4.5	4.5	4.5	30	48
1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	2	2	4.5	4.5	4.5	31	49.6
1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	2	2	4.5	4.5	2	32	51.2
1	1	1	1	1	1	1	1	1	2	1	2	1	2	1	2	2	4.5	4.5	2	33	52.8
1	1	1	1	1	1	1	2	1	2	1	2	1	2	1	2	2	4.5	4.5	2	34	54.4
1	1	1	1	2	1	1	2	1	2	1	2	1	2	1	2	2	4.5	4.5	2	35	56
1	2	1	1	2	1	1	2	1	2	1	2	1	2	1	2	2	4.5	4.5	2	36	57.6
1	2	1	1	2	1	1	2	1	2	1	2	1	2	2	2	2	4.5	4.5	2	37	59.2
2	2	1	1	2	1	1	2	1	2	1	2	1	2	2	2	2	4.5	4.5	2	38	60.8
3	4	3	3	4	3	3	4	3	4	3	4	3	4	3	4	4	4.5	4.5	4	72	115.2
3	4	3	3	4	3	3	4	3	4	3	4	3	4	4	4	4	4.5	4.5	4	73	116.8
4	4	3	3	4	3	3	4	3	4	3	4	3	4	4	4	4	4.5	4.5	4	74	118.4
4	4	3	3	4	4	3	4	3	4	3	4	3	4	4	4	4	4.5	4.5	4	75	120
4	4	4	3	4	4	3	4	3	4	3	4	3	4	4	4	4	4.5	4.5	4	76	121.6
4	4	4	4	4	4	3	4	3	4	3	4	3	4	4	4	4	4.5	4.5	4	77	123.2
4	4	4	4	4	4	3	4	3	4	3	4	4	4	4	4	4	4.5	4.5	4	78	124.8
4	4	4	4	4	4	4	4	3	4	3	4	4	4	4	4	4	4.5	4.5	4	79	126.4
4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4.5	4.5	4	80	128
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4.5	4.5	4	81	129.6
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4.5	4.5	4	82	131.2
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4.5	4.5	5	83	132.8
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	4.5	4.5	5	84	134.4
4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	5	5	4.5	4.5	5	85	136
4	4	4	4	4	4	4	4	4	4	4	5	4	5	4	5	5	4.5	4.5	5	86	137.6
4	4	4	4	4	4	4	4	4	5	4	5	4	5	4	5	5	4.5	4.5	5	87	139.2

(Sheet 2 of 4)

Table A1 (Continued)

Spillway Bay Numbers																					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	STOPS	KCFS
4	4	4	4	4	4	4	5	4	5	4	5	4	5	4	5	5	4.5	4.5	5	88	140.8
4	4	4	4	5	4	4	5	4	5	4	5	4	5	4	5	5	4.5	4.5	5	89	142.4
4	5	4	4	5	4	4	5	4	5	4	5	4	5	4	5	5	4.5	4.5	5	90	144
4	5	4	4	5	4	4	5	4	5	4	5	4	5	5	5	5	4.5	4.5	5	91	145.6
5	5	4	4	5	4	4	5	4	5	4	5	4	5	5	5	5	4.5	4.5	5	92	147.2
5	5	4	4	5	5	4	5	4	5	4	5	4	5	5	5	5	4.5	4.5	5	93	148.8
5	5	5	4	5	5	4	5	4	5	4	5	4	5	5	5	5	4.5	4.5	5	94	150.4
5	5	5	5	5	5	4	5	4	5	4	5	4	5	5	5	5	4.5	4.5	5	95	152
5	5	5	5	5	5	4	5	4	5	4	5	5	5	5	5	5	4.5	4.5	5	96	153.6
5	5	5	5	5	5	5	5	4	5	4	5	5	5	5	5	5	4.5	4.5	5	97	155.2
5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	4.5	4.5	5	98	156.8
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4.5	4.5	5	99	158.4
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	5	4.5	4.5	5	100	160
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	4.5	4.5	6	101	161.6
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	4.5	4.5	6	102	163.2
5	5	5	5	5	5	5	5	5	5	5	5	5	6	5	6	6	4.5	4.5	6	103	164.8
5	5	5	5	5	5	5	5	5	5	5	6	5	6	5	6	6	4.5	4.5	6	104	166.4
5	5	5	5	5	5	5	5	5	6	5	6	5	6	5	6	6	4.5	4.5	6	105	168
5	5	5	5	5	5	5	6	5	6	5	6	5	6	5	6	6	4.5	4.5	6	106	169.6
5	5	5	5	6	5	5	6	5	6	5	6	5	6	5	6	6	4.5	4.5	6	107	171.2
5	6	5	5	6	5	5	6	5	6	5	6	5	6	5	6	6	4.5	4.5	6	108	172.8
5	6	5	5	6	5	5	6	5	6	5	6	5	6	6	6	6	4.5	4.5	6	109	174.4
6	6	5	5	6	5	5	6	5	6	5	6	5	6	6	6	6	4.5	4.5	6	110	176
6	6	5	5	6	6	5	6	5	6	5	6	5	6	6	6	6	4.5	4.5	6	111	177.6
6	6	6	5	6	6	5	6	5	6	5	6	5	6	6	6	6	4.5	4.5	6	112	179.2

(Sheet 3 of 4)

Table A1 (Concluded)

Spillway Bay Numbers																					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	STOPS	KCPS
6	6	6	6	6	6	5	6	5	6	5	6	5	6	6	6	6	4.5	4.5	6	113	180.8
6	6	6	6	6	6	5	6	5	6	5	6	6	6	6	6	6	4.5	4.5	6	114	182.4
6	6	6	6	6	6	6	6	5	6	5	6	6	6	6	6	6	4.5	4.5	6	115	184
6	6	6	6	6	6	6	6	5	6	6	6	6	6	6	6	6	4.5	4.5	6	116	185.6
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	4.5	4.5	6	117	187.2
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7	6	4.5	4.5	6	118	188.8
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7	4.5	4.5	7	119	190.4
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7	7	4.5	4.5	7	120	192
6	6	6	6	6	6	6	6	6	6	6	6	6	7	6	7	7	4.5	4.5	7	121	193.6
6	6	6	6	6	6	6	6	6	6	6	7	6	7	6	7	7	4.5	4.5	7	122	195.2
6	6	6	6	6	6	6	6	6	7	6	7	6	7	6	7	7	4.5	4.5	7	123	196.8
6	6	6	6	6	6	6	7	6	7	6	7	6	7	6	7	7	4.5	4.5	7	124	198.4
6	6	6	6	7	6	6	7	6	7	6	7	6	7	6	7	7	4.5	4.5	7	125	200
6	7	6	6	7	6	6	7	6	7	6	7	6	7	6	7	7	4.5	4.5	7	126	201.6

(Sheet 4 of 4)

Table A2
1998 Spill Schedule for John Day Dam

Spillway Bay Numbers																				STOPS	KCFS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
2	2	2																		6	9.6
2	3	2																		7	11.2
2	3	2	1																	8	12.8
2	3	2	2																	9	14.4
2	3	3	2																	10	16
2	3	3	2	1																11	17.6
2	3	3	2	2																12	19.2
2	3	3	2	2	1															13	20.8
2	3	3	2	2	2															14	22.4
2	3	3	2	2	2	1														15	24
2	3	3	2	2	2	2														16	25.6
2	3	3	2	2	2	2	1													17	27.2
2	3	3	3	2	2	2	1													18	28.8
2	3	3	3	2	2	2	2													19	30.4
2	3	3	3	2	2	2	2	1												20	32
2	3	3	3	3	2	2	2	1												21	33.6
2	3	3	3	3	3	2	2	1												22	35.2
2	3	3	3	3	3	2	2	2												23	36.8
2	3	3	3	3	3	2	2	2	1											24	38.4
2	3	3	3	3	3	2	2	2	2											25	40
2	3	3	3	3	3	2	2	2	2	1										26	41.6
2	3	3	3	3	3	2	2	2	2	2										27	43.2
2	3	3	3	3	3	2	2	2	2	2	1									28	44.8
2	3	3	3	3	3	2	2	2	2	2	2									29	46.4
2	3	3	3	3	3	3	2	2	2	2	2									30	48

(Sheet 1 of 5)

Table A2 (Continued)

Spillway Bay Numbers																				STOPS	KCFS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
2	3	3	3	3	3	3	2	2	2	2	2	1								31	49.6
2	3	3	3	3	3	3	2	2	2	2	2	2								32	51.2
2	3	3	3	3	3	3	2	2	2	2	2	2	1							33	52.8
2	3	3	3	3	3	3	3	2	2	2	2	2	1							34	54.4
2	3	3	3	3	3	3	3	2	2	2	2	2	2							35	56
2	3	3	3	3	3	3	3	2	2	2	2	2	2	1						36	57.6
2	3	3	3	3	3	3	3	2	2	2	2	2	2	2						37	59.2
2	3	3	3	3	3	3	3	2	2	2	2	2	2	2	1					38	60.8
2	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2					39	62.4
2	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	1				40	64
2	4	3	3	3	3	3	3	2	2	2	2	2	2	2	2	1				41	65.6
2	4	4	3	3	3	3	3	2	2	2	2	2	2	2	2	1				42	67.2
2	4	4	4	3	3	3	3	2	2	2	2	2	2	2	2	1				43	68.8
2	4	4	4	4	3	3	3	2	2	2	2	2	2	2	2	1				44	70.4
2	4	4	4	4	3	3	3	3	2	2	2	2	2	2	2	1				45	72
2	4	4	4	4	3	3	3	3	3	2	2	2	2	2	2	1				46	73.6
3	4	4	4	4	3	3	3	3	3	2	2	2	2	2	2	1				47	75.2
3	5	4	4	4	3	3	3	3	3	2	2	2	2	2	2	1				48	76.8
3	5	5	4	4	3	3	3	3	3	2	2	2	2	2	2	1				49	78.4
3	5	5	4	4	4	3	3	3	2	2	2	2	2	2	2	2				50	80
3	5	5	4	4	4	3	3	3	2	2	2	2	2	2	2	2	1			51	81.6
3	5	5	4	4	4	3	3	3	3	2	2	2	2	2	2	2	1			52	83.2
3	5	5	4	4	4	3		3	3	3	2	2	2	2	2	2	1			53	84.8
3	5	5	4	4	4	3	3	3	3	3	3	2	2	2	2	2	1			54	86.4
3	5	5	5	4	4	3	3	3	3	3	3	2	2	2	2	2	1			55	88
3	5	5	5	4	4	4	3	3	3	3	3	2	2	2	2	2	1			56	89.6

(Sheet 2 of 5)

Table A2 (Continued)

Spillway Bay Numbers																					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	STOPS	KCFS
3	5	5	5	4	4	4	3	3	3	3	3	3	2	2	2	2	1			57	91.2
3	5	5	5	4	4	4	3	3	3	3	3	3	3	2	2	2	1			58	92.8
3	5	5	5	4	4	4	3	3	3	3	3	3	3	3	2	2	1			59	94.4
3	5	5	5	4	4	4	3	3	3	3	3	3	3	3	3	2	1			60	96
3	5	5	5	4	4	4	4	3	3	3	3	3	3	3	3	2	1			61	97.6
3	5	5	5	4	4	4	4	4	3	3	3	3	3	3	3	2	1			62	99.2
3	5	5	5	5	4	4	4	4	3	3	3	3	3	3	3	2	1			63	100.8
3	5	5	5	5	4	4	4	4	3	3	3	3	3	3	3	2	2			64	102.4
3	5	5	5	5	4	4	4	4	4	3	3	3	3	3	3	2	2			65	104
3	5	5	5	5	4	4	4	4	4	3	3	3	3	3	3	2	2	1		66	105.6
3	5	5	5	5	4	4	4	4	4	3	3	3	3	3	3	3	2	1		67	107.2
4	4	4	4	4	3	3	3	3	3	3	3	3	3	4	3	4	3	4	3	68	108.8
4	4	4	4	4	3	3	4	3	3	3	3	3	3	4	3	4	3	4	3	69	110.4
4	4	4	4	4	3	3	4	3	4	3	3	3	3	4	3	4	3	4	3	70	112
4	4	4	4	4	3	3	4	3	4	3	4	3	3	4	3	4	3	4	3	71	113.6
4	4	4	4	4	3	4	3	4	3	4	3	3	4	4	3	4	3	4	3	72	115.2
4	4	4	4	4	3	4	3	4	3	4	3	3	4	4	3	4	4	4	3	73	116.8
4	4	4	4	4	3	4	3	4	3	4	3	3	4	4	4	4	4	4	3	74	118.4
4	4	4	4	4	3	4	3	4	3	4	3	4	4	4	4	4	4	4	3	75	120
4	4	4	4	4	4	4	3	4	3	4	3	4	4	4	4	4	4	4	3	76	121.6
4	4	4	4	4	4	4	4	4	3	4	3	4	4	4	4	4	4	4	3	77	123.2
4	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	3	78	124.8
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	79	126.4
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	80	128
5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	81	129.6
5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	82	131.2

(Sheet 3 of 5)

Table A2 (Continued)

Spillway Bay Numbers																					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	STOPS	KCFS
5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	83	132.8
5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	84	134.4
5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	85	136
5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	5	4	5	4	86	137.6
5	5	5	5	4	4	4	4	4	4	4	4	4	4	5	4	5	4	5	4	87	139.2
5	5	5	5	5	4	4	4	4	4	4	4	4	4	5	4	5	4	5	4	88	140.8
5	5	5	5	5	4	4	5	4	4	4	4	4	4	5	4	5	4	5	4	89	142.4
5	5	5	5	5	4	4	5	4	5	4	4	4	4	5	4	5	4	5	4	90	144
5	5	5	5	5	4	4	5	4	5	4	5	4	4	5	4	5	4	5	4	91	145.6
5	5	5	5	5	5	4	5	4	5	4	5	4	4	5	4	5	4	5	4	92	147.2
5	5	5	5	5	5	4	5	4	5	4	5	4	4	4	5	5	5	5	4	93	148.8
5	5	5	5	5	5	4	5	4	5	4	5	4	4	5	5	5	5	5	4	94	150.4
5	5	5	5	5	5	5	5	4	5	4	5	4	4	5	5	5	5	5	4	95	152
5	5	5	5	5	5	5	5	4	5	4	5	4	5	5	5	5	5	5	4	96	153.6
5	5	5	5	5	5	5	5	5	5	4	5	4	5	5	5	5	5	5	4	97	155.2
5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	4	98	156.8
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	99	158.4
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	100	160
6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	101	161.6
6	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	102	163.2
6	6	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	103	164.8
6	6	6	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	104	166.4
6	6	6	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	5	105	168
6	6	6	6	5	5	5	5	5	5	5	5	5	5	5	5	6	5	6	5	106	169.6
6	6	6	6	5	5	5	5	5	5	5	5	5	5	6	5	6	5	6	5	107	171.2
6	6	6	6	6	5	5	5	5	5	5	5	5	5	6	5	6	5	6	5	108	172.8

(Sheet 4 of 5)

Table A2 (Concluded)

Spillway Bay Numbers																					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	STOPS	KCFS
6	6	6	6	6	5	5	6	5	5	5	5	5	5	6	5	6	5	6	5	109	174.4
6	6	6	6	6	5	5	6	5	6	5	5	5	5	6	5	6	5	6	5	110	176
6	6	6	6	6	5	5	6	5	6	5	6	5	5	6	5	6	5	6	5	111	177.6
6	6	6	6	6	6	5	6	5	6	5	6	5	5	6	5	6	5	6	5	112	179.2
6	6	6	6	6	6	5	6	5	6	5	6	5	5	6	5	6	6	6	5	113	180.8
6	6	6	6	6	6	5	6	5	6	5	6	5	5	6	6	6	6	6	5	114	182.4
6	6	6	6	6	6	6	6	5	6	5	6	5	5	6	6	6	6	6	5	115	184
6	6	6	6	6	6	6	6	5	6	5	6	5	6	6	6	6	6	6	5	116	185.6
6	6	6	6	6	6	6	6	6	6	5	6	5	6	6	6	6	6	6	5	117	187.2
6	6	6	6	6	6	6	6	6	6	6	6	5	6	6	6	6	6	6	5	118	188.8
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	119	190.4
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	120	192
7	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	121	193.6
7	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	122	195.2
7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	123	196.8
7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	124	198.4
7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7	6	125	200
7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	7	6	7	6	126	201.6
7	7	7	7	6	6	6	6	6	6	6	6	6	6	7	6	7	6	7	6	127	203.2
7	7	7	7	7	6	6	6	6	6	6	6	6	6	7	6	7	6	7	6	128	204.8
7	7	7	7	7	6	6	7	6	6	6	6	6	6	7	6	7	6	7	6	129	206.4
7	7	7	7	7	6	6	7	6	7	6	6	6	6	7	6	7	6	7	6	130	208
7	7	7	7	7	6	6	7	6	7	6	7	6	6	7	6	7	6	7	6	131	209.6

(Sheet 5 of 5)

Table A3
1999 Spill Schedule for John Day Dam

Spillway Bay Numbers																					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	STOPS	KCFS
2	2	2																		6	9.6
2	3	2																		7	11.2
2	3	2	1																	8	12.8
2	3	2	2																	9	14.4
2	3	3	2																	10	16
2	3	3	2	1																11	17.6
2	3	3	2	2																12	19.2
2	3	3	2	2	1															13	20.8
2	3	3	2	2	2															14	22.4
2	3	3	2	2	2	1														15	24
2	3	3	2	2	2	2														16	25.6
2	3	3	2	2	2	2	1													17	27.2
2	3	3	3	2	2	2	1													18	28.8
2	3	3	3	2	2	2	2													19	30.4
2	3	3	3	2	2	2	2	1												20	32
2	3	3	3	3	2	2	2	1												21	33.6
2	3	3	3	3	3	2	2	1												22	35.2
2	3	3	3	3	3	2	2	2												23	36.8
2	3	3	3	3	3	2	2	2	1											24	38.4
2	3	3	3	3	3	2	2	2	2											25	40
2	3	3	3	3	3	2	2	2	2	1										26	41.6
2	3	3	3	3	3	2	2	2	2	2										27	43.2
2	3	3	3	3	3	2	2	2	2	2	1									28	44.8
2	3	3	3	3	3	2	2	2	2	2	2									29	46.4

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Table A3 (Continued)

Spillway Bay Numbers																					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	STOPS	KCFS
2	3	3	3	3	3	3	2	2	2	2	2									30	48
2	3	3	3	3	3	3	2	2	2	2	2	1								31	49.6
2	3	3	3	3	3	3	2	2	2	2	2	2								32	51.2
2	3	3	3	3	3	3	2	2	2	2	2	2	1							33	52.8
2	3	3	3	3	3	3	3	2	2	2	2	2	1							34	54.4
2	3	3	3	3	3	3	3	2	2	2	2	2	2							35	56
2	3	3	3	3	3	3	3	2	2	2	2	2	2	1						36	57.6
2	3	3	3	3	3	3	3	2	2	2	2	2	2	2						37	59.2
2	3	3	3	3	3	3	3	2	2	2	2	2	2	2	1					38	60.8
2	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2					39	62.4
2	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	1				40	64
2	4	3	3	3	3	3	3	2	2	2	2	2	2	2	2	1				41	65.6
2	4	4	3	3	3	3	3	2	2	2	2	2	2	2	2	1				42	67.2
2	4	4	4	3	3	3	3	2	2	2	2	2	2	2	2	1				43	68.8
2	4	4	4	4	3	3	3	2	2	2	2	2	2	2	2	1				44	70.4
2	4	4	4	4	3	3	3	3	2	2	2	2	2	2	2	1				45	72
2	4	4	4	4	3	3	3	3	3	2	2	2	2	2	2	1				46	73.6
3	4	4	4	4	3	3	3	3	3	2	2	2	2	2	2	1				47	75.2
3	5	4	4	4	3	3	3	3	3	2	2	2	2	2	2	1				48	76.8
3	5	5	4	4	3	3	3	3	3	2	2	2	2	2	2	1				49	78.4
3	5	5	4	4	4	3	3	3	2	2	2	2	2	2	2	2				50	80
3	5	5	4	4	4	3	3	3	2	2	2	2	2	2	2	2	1			51	81.6
3	5	5	4	4	4	3	3	3	3	2	2	2	2	2	2	2	1			52	83.2
3	5	5	4	4	4	3	3	3	3	3	2	2	2	2	2	2	1			53	84.8
3	5	5	4	4	4	3	3	3	3	3	3	2	2	2	2	2	1			54	86.4

(Sheet 2 of 6)

Table A3 (Continued)

Spillway Bay Numbers																					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	STOPS	KCFS
3	5	5	5	4	4	3	3	3	3	3	3	2	2	2	2	2	1			55	88
3	5	5	5	4	4	4	3	3	3	3	3	2	2	2	2	2	1			56	89.6
3	5	5	5	4	4	4	3	3	3	3	3	3	2	2	2	2	1			57	91.2
3	5	5	5	4	4	4	3	3	3	3	3	3	3	2	2	2	1			58	92.8
3	5	5	5	4	4	4	3	3	3	3	3	3	3	3	2	2	1			59	94.4
3	5	5	5	4	4	4	3	3	3	3	3	3	3	3	3	2	1			60	96
3	5	5	5	4	4	4	4	3	3	3	3	3	3	3	3	2	1			61	97.6
3	5	5	5	4	4	4	4	4	3	3	3	3	3	3	3	2	1			62	99.2
3	5	5	5	5	4	4	4	4	3	3	3	3	3	3	3	2	1			63	100.8
3	5	5	5	5	4	4	4	4	3	3	3	3	3	3	3	2	2			64	102.4
3	5	5	5	5	4	4	4	4	4	3	3	3	3	3	3	2	2			65	104
3	5	5	5	5	4	4	4	4	4	3	3	3	3	3	3	2	2	1		66	105.6
3	5	5	5	5	4	4	4	4	4	3	3	3	3	3	3	3	2	1		67	107.2
3	5	5	5	4	4	4	4	4	4	3	3	3	3	3	3	3	3	1	1	68	108.8
3	5	5	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	2	1	69	110.4
3	5	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	2	1	70	112
4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	2	1	71	113.6
4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	2	1	72	115.2
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	2	1	73	116.8
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	2	1	74	118.4
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	2	1	75	120
5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	1	76	121.6
5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	1	77	123.2
5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	1	78	124.8
5	5		5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	1	79	126.4

(Sheet 3 of 6)

Table A3 (Continued)

Spillway Bay Numbers																					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	STOPS	KCFS
5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	2	1	80	128
5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	2	1	81	129.6
5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	2	1	82	131.2
5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	2	1	83	132.8
5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	2	1	84	134.4
5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	2	1	85	136
5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	2	1	86	137.6
5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	2	1	87	139.2
5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	2	1	88	140.8
5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	2	1	89	142.4
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	2	1	90	144
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	2	1	91	145.6
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	2	1	92	147.2
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	2	1	93	148.8
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	1	94	150.4
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	2	95	152
6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	2	96	153.6
6	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	2	97	155.2
6	6	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	2	98	156.8
6	6	6	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	2	99	158.4
6	6	6	6	6	5	5	5	5	5	5	5	5	5	5	5	5	5	3	2	100	160
6	6	6	6	6	6	5	5	5	5	5	5	5	5	5	5	5	5	3	2	101	161.6
6	6	6	6	6	6	6	5	5	5	5	5	5	5	5	5	5	5	3	2	102	163.2
6	6	6	6	6	6	6	6	5	5	5	5	5	5	5	5	5	5	3	2	103	164.8
6	6	6	6	6	6	6	6	6	5	5	5	5	5	5	5	5	5	3	2	104	166.4

(Sheet 4 of 6)

Table A3 (Continued)

Spillway Bay Numbers																					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	STOPS	KCFS
6	6	6	6	6	6	6	6	6	6	5	5	5	5	5	5	5	5	3	2	105	168
6	6	6	6	6	6	6	6	6	6	6	5	5	5	5	5	5	5	3	2	106	169.6
6	6	6	6	6	6	6	6	6	6	6	6	5	5	5	5	5	5	3	2	107	171.2
6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	5	5	5	3	2	108	172.8
6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	5	5	3	2	109	174.4
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	5	3	2	110	176
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	3	2	111	177.6
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	3	2	112	179.2
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	3	2	113	180.8
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	4	2	114	182.4
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	4	3	115	184
7	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	4	3	116	185.6
7	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	4	3	117	187.2
7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	4	3	118	188.8
7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6	4	3	119	190.4
7	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	6	4	3	120	192
7	7	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	4	3	121	193.6
7	7	7	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	4	3	122	195.2
7	7	7	7	7	7	7	7	6	6	6	6	6	6	6	6	6	6	4	3	123	196.8
7	7	7	7	7	7	7	7	7	6	6	6	6	6	6	6	6	6	4	3	124	198.4
7	7	7	7	7	7	7	7	7	7	6	6	6	6	6	6	6	6	4	3	125	200
7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	6	6	6	4	3	126	201.6
7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	6	6	4	3	127	203.2
7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	6	4	3	128	204.8
7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	4	3	129	206.4

(Sheet 5 of 6)

Table A3 (Concluded)

Spillway Bay Numbers																					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	STOPS	KCFS
7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	4	3	130	208
7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	4	3	131	209.6
7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	4	3	132	211.2
7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	4	3	133	212.8
7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	5	3	134	214.4
7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	5	4	135	216.0
8	7	7	7	7	7	7		7	7	7	7	7		7	7	7	7	5	4	136	217.6
8	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	5	4	137	219.2
8	8	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	5	4	138	220.8
8	8	8	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	5	4	139	222.4

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14. ABSTRACT

Representatives of the Columbia River Towing Association reported recent structural and/or operational changes at John Day Lock and Dam have created difficult navigation conditions for tows entering or leaving the lower lock approach. Therefore, the U.S. Army Engineer District, Portland, decided to use the existing 1:80-scale fixed-bed model of John Day Lock and Dam located at the U.S. Army Engineer Research and Development Center to investigate and document conditions in the lower lock approach before and after the changes. This report describes the model and prototype experiments conducted to investigate and document navigation conditions before and after the structural and operations changes.

15. SUBJECT TERMS

John Day Lock and Dam	Current direction	Fish migration
Columbia River	Current velocity	Fixed bed model

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
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